



The Blast Furnace and Steel Plant

Published the first of each month by the National Iron and Steel Publishing Co.

Main Office — Thaw Building, 108 Smithfield Street, Pittsburgh.

DISTRICT OFFICES — NEW YORK AND CHICAGO.

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Subscription Price:—In the United States, \$1 per year; Canada, \$1.50; all other countries, \$2. Single Copy, 15 Cents.
Entered as second-class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

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VOL. VI.

APRIL, 1918.

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The Blast Furnace *and* Steel Plant

Modern Blast Furnace at Portsmouth, Ohio

New Five-Hundred-Ton Furnace to Be Operated in Connection With a Battery of Semet-Solvay Coke Ovens — Furnace Has Unique Dust Catcher, Having Two Chambers Instead of One.

The following is a description of the plant of the Whitaker-Glessner Co., at Portsmouth, O., which was completed and put into operation during the latter months of the year of 1917. The furnace was hampered and held back from the start by the prevailing shortage of coke. But the completion of two blocks of Solvay coke ovens, in the near future, is expected to overcome this difficulty. The construction of the furnace was done by William Pollock Company, of Youngstown, O. Julian Kennedy was the designing engineer, and it is through his courtesy that it is possible to present this reliable and accurate information concerning a plant which embodies the most up-to-date practice in the design of a furnace for the conditions this one is built to meet.

This furnace was built to supply iron to furnish pig iron to the old Whitaker-Glessner Co. steel plant, which operates open hearth furnaces, and produces a variety of rolled and finished products, including sheets, plates, roofing, billets, slabs, tie plates, blue annealed sheets, one-pass cold rolled sheets, galvanized sheets, galvanized roofing, and black and galvanized sheet barrels. The furnace operates on lake ores, being situated on a direct rail connection from Lake Erie and is also located near the outlet of supply of coking coal from the coal fields of Eastern Kentucky and West Virginia. Fig. 1 shows the general layout of the plant. The steel works adjoins the furnace property on the west and the Portsmouth-Solvay Coke Company's plant is on the ground lying to the east.

Stock Yard and Ore Bins.

The stock yard measures 500 by 240 feet, and the ore can be stored in sufficient quantities to insure a five- or six-months' run. A concrete retaining wall at one end is necessary on account of the topography; the other end is open. A Heyl & Patterson ore bridge serves the stock yard and delivers the ore into an electric transfer car over the ore bins.

The bins are of Hoover & Mason construction, with roller gates discharging ore and stone into a single compartment scale car, having a capacity of 14,000 pounds. The coke bin is directly in front of the skip bucket pit

and discharges directly into the skip bucket through a chute that passes under the scale car track.

Hoisting Mechanism and Top.

The burden is dumped into a skip bucket of steel plate construction and having a maximum capacity of 14,000 pounds of ore. The bucket is supported from the skip carriage by a large shaft, on the bottom of which is mounted the bell. The bottom edge of the bucket rests on the bell. Two hydraulic cylinders at the skip pit oper-

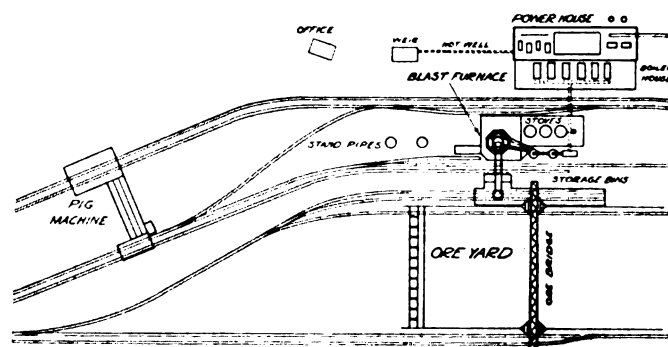


Fig. 1—General layout of plant.

ate racks which engage with a gear mounted on the vertical shaft supporting the bucket. This arrangement makes it possible to turn the bucket 120 degrees in either direction and a three-point distribution is thus obtained by using one or the other, or neither of the hydraulic cylinders immediately after the charge has been dumped into the bucket.

The charge is lifted to the top of the furnace by an Otis Elevator Company geared hoist operating at 230 volts. Two counter-weights are attached to the system. One operates on the hoisting drum direct and the other is connected to the skip carriage in such a way that it acts as a check on the motion of the bucket and carriage from the time the bucket reaches its highest position till it settles into place on top of the furnace to deposit its charge on the main furnace bell. After the bucket has settled into place the carriage continues to move, which lowers the bell in the bottom of the bucket and allows the charge to drop

into the hopper over the furnace bell. The skip carriage is a special Julian Kennedy design with four pairs of flanged wheels connected into two trucks, to which the bucket is attached with a pantagraph linkage which keeps the bucket in a vertical position at all times and insures correct seating at the top.

The furnace bell has a diameter of 13 feet and

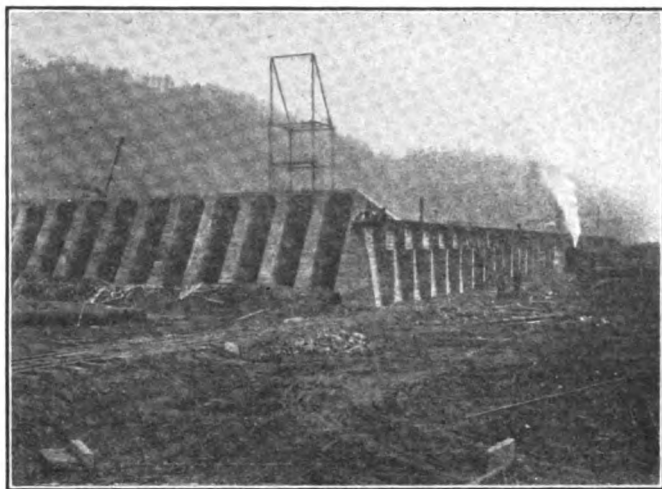


Fig. 2—Blast furnace foundation and ore bins.

is operated by a 12-inch diameter hydraulic cylinder located above the hoisting mechanism, connecting with it by means of two side rods running down on opposite sides of the skip bucket, and giving the bell a drop of 2 feet. The hole above the bell in which the skip bucket seats is normally covered by a plate slide operated by a hydraulic cylinder. This slide is opened only when the bucket is at the top of the furnace. This device gives the furnace all the advantages of a double bell top without materially increasing complications.

The controls of the entire hoisting and charging mechanism consists of four hydraulic valves and an Otis elevator controller similar to those seen in passenger elevators, all located in a room at one side of the skip hoist on the level of the scale car track, where they can be manipulated by a single operator.

Furnace Proper.

The furnace stack is 92 feet high from the center line of the tapping hole to the platform at the top, and has the following dimensions: Hearth, 17 feet in diameter; bosh angle, 78 degrees 14 seconds; bosh, 22 feet in diameter; stock line, 17 feet in diameter. The walls of the bosh are 2 feet 3 inches thick, and the walls above the mantle are 3 feet 4½ inches thick. The blast is blown in through 12 6-inch tuyeres. The stack is supported by six cast iron columns. The hearth is inclosed in a 1½-inch plate jacket, and the tuyere breast has a 1¼-inch jacket. The entire construction is very heavy and gives the appearance of being safe and sub-

stantial. The stock line is protected by cast iron segments. The bosh and tuyere breast are cooled by bronze plates with curved tops.

Stoves and Gas Handling Apparatus.

The gas leaves the top of the furnace through four downcomer openings to which are connected two cast steel elbows to turn the gas in a downward direction. These elbows have ribs cast around the interior to resist the sand blast action of the particles of ore and coke that come over. These four pipes come together into two unlined steel plate pipes which enter the dust catcher near the top. The dust catcher is a unique design, having two chambers in place of the usual one. They are 18 feet in diameter and arranged one above the other as may be seen from the illustration. The lower chamber acts as a settling basin for the dust that is caught in the upper chamber, and makes it impossible for the dust to be stirred up again into the gas current after it has once been separated out. When the dust is dumped from the bottom chamber it passes through a chute into a car standing on the track on the charging side of the furnace. From the dust catcher the gas passes through a Brassert-Bacon gas washer and through a horizontal cylindrical drier and from thence the gas goes to the stoves and the boilers. All the gas mains are equipped with washout devices at regular intervals along the pipe, which consists of a nozzle on a bent pipe mounted on a spherical slip-joint, where it enters the main, so it can be turned and moved in any direction when washing out the main.

The regenerator equipment consists of three two-pass

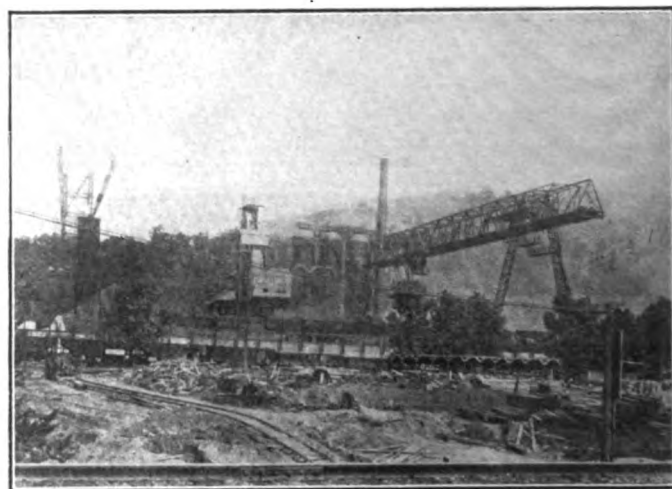


Fig. 3—General view of blast furnace, showing ore bridge, bins, stoves, dust catcher, etc.

side combustion stoves 24 feet in diameter and 110 feet high. The stoves are heat-insulated with J.-M. asbestos block 2 inches thick. The hot blast main and bustle pipe are insulated with the same material. The stove burners are a special Julian Kennedy design. The hot blast valves are Mathesius patent gate valves. The burnt gases from

the stoves are carried away by a brick stack 190 feet high. This is an example of the present tendency toward the use of a small number of stoves of comparatively large capacity.

Boiler House and Power Plant.

The boilers and power plant are housed in one building with a brick wall between. The boiler equipment consists of six Babcock & Wilcox units with individual chimneys directly over the settings. Each boiler is fired by six 10-inch Burkholtz blast furnace gas burners and has arrangement for supplementary coal firing. This boiler equipment, along with the type of stoves used makes a very efficient use of the furnace gas and cuts down the use of other fuel to a minimum for this type of plant.

Within the power house are housed the turbo-blowers, turbo-generators, condensers, and pumps necessary for supplying the hydraulic power. It has the small size, arrangement and general neatness characteristic of plants using that type of equipment. The switchboard is elevated on a platform and is an example of good and simplified arrangement.

The blast is furnished by two Ingersoll-Rand turbo-blowers having a rated capacity of 45,000 cubic feet of atmospheric air per minute, and having a pressure range up to 30 pounds per square inch. Each blower is capable of furnishing sufficient blast for the furnace. The air intake is through two vertical pipes outside of the building which are screened at the openings and covered at the top which is near the roof of the power house.

The electric power is supplied by two General Electric

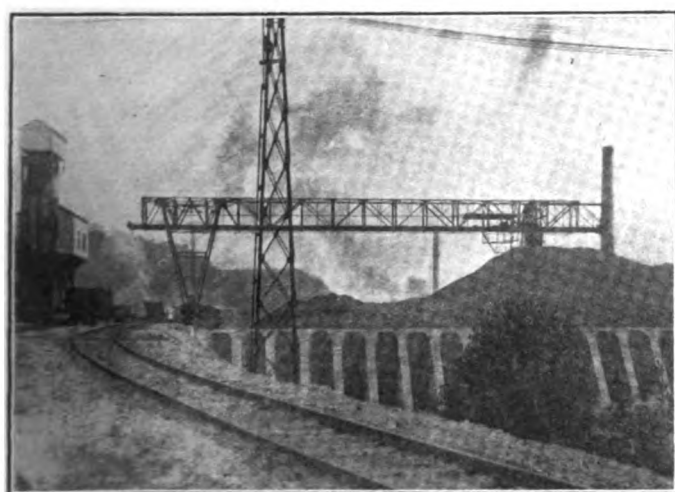


Fig. 4—Stock yard showing concrete work.

turbo-generators of 3,000 kilowatt capacity each, which operate tied in with the machines in the power house of the steel plant. Two motor generator General Electric sets supply the direct current needed about the blast furnace. An air cleaner furnished by the Spray Engineering

Company is used to clean the cooling air for the electrical equipment.

Both the turbo-generators and blowers are equipped with Schutte & Koerting jet condensers without air pumps. The cooling water for the condensers is

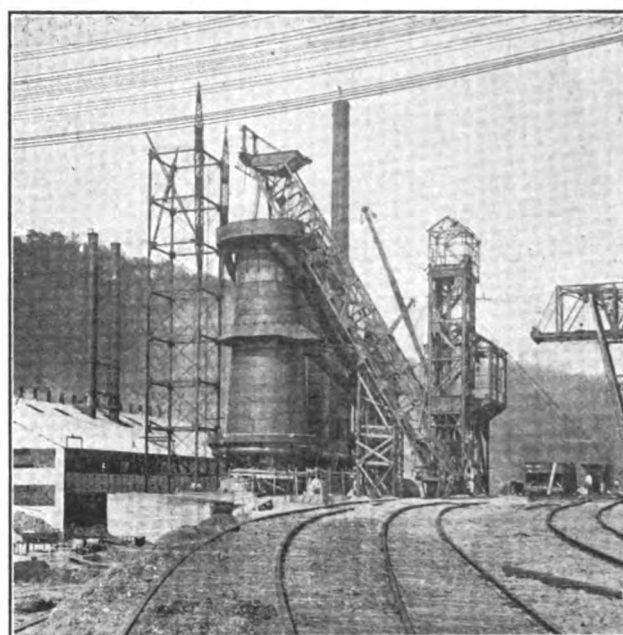


Fig. 5—Blast furnace in course of construction.

taken from the Ohio river by centrifugal pumps located on the river bank. The water is pumped from the river into a low-pressure standpipe 24 feet in diameter and 40 feet high, to keep a constant head on the condensers. The inlet to the standpipe is controlled by a float operated valve to prevent overflowing. From the condensers the water is discharged into a hot well running the entire length of the power house, and extending to a sewer outside, where the excess escapes. A great part of the water in the hot well is picked up by centrifugal pumps and discharged into the high pressure standpipe which is 20 feet in diameter and 110 feet high, to supply the blast furnace and stoves with cooling water, and connects with the 24-inch supply line to the steel works. Part of the water from the low pressure standpipe is pumped direct to the gas washer. All the pumps are DeLaval centrifugal type, furnished by the Dravo-Doyle Company.

Disposal of the Iron and Slag.

The iron is tapped from the furnace and runs into a 75 ton ladle and is transported to the pig machine. The pig machine is a two-strand machine made by the Heyl & Patterson Co., and operated by a 75-horsepower motor. Hot metal for the open hearth is transpoured at the pig machine into a special 30-ton open hearth charging car.

The slag is handled hot in ladles, but an arrangement is to be made whereby it can be granulated in standard gauge cars.

Making Substitutions for Natural Gas

The Cost and Operation of Fuel Oil, Powdered Coal and Producer Gas Are Considered—Cost of Changing from One Type of Fuel to Another Not Considered.

By F. DENK.

The prevailing shortage of natural gas has forced many a manufacturing concern to look out for some other fuel, in order to be able to run the factory during the coming winter. The fuels considered in this article are fuel oil, powdered coal and producer gas.

Where the change from natural gas to the new fuel has to be made quickly, the only thing to do is to install fuel oil. Such an installation, however, should always be considered as an emergency only on account of the high cost of the raw material. While the plant is working with the new fuel, provisions should be made for operating the plant later on with producer gas, or, if conditions should warrant it, with powdered coal. The reason for this statement can easily be seen from the following short calculation:

One gallon of fuel oil contains 140,000 B.t.u., and thus corresponds to 10 pounds of coal, having a heating value of 14,000 B.t.u. per pound. If the price is 6 cents

a gallon, the equivalent price of coal is $\frac{.06 \times 2,000}{10} =$

\$12 per ton. For 8 cents a gallon this amount increases to \$16 per ton. Considering that, at present, the price of coal at the mine is \$2.45, to which has to be added a certain amount for freight, it can easily be seen, that the equivalent price for oil, given above, is far too high to warrant its general use under prevailing conditions. But, as was stated before, the fact that a fuel oil plant can be erected and installed quickly and at a proportionately low cost, gives it a certain advantage over the other substitutes for natural gas.

The application of powdered coal as a fuel has, in this country, not made the same progress during the last decade that it has in Europe, which may be mostly due to the high prices of coal over there, which forced the manufacturers to turn to a cheaper fuel, which they found in powdered coal (at least to a certain extent), being able to use for this purpose coal screenings and lower grades of coal, which could not be used to advantage otherwise. In the United States some installations using powdered coal have been running successfully for several years, while it is only during the last few years that some larger plants have turned to this fuel. Reliable test data, however, have not yet been published. Several methods of grinding the coal and conveying the powdered material to the furnaces have been developed, but, nevertheless, up to the present time, the use of powdered coal has been mostly confined to certain types of furnaces,

e. i., those used in the cement industry, in blacksmith and drop forge shops, etc., and also to a limited extent, to boilers, while the large furnaces like those used in steel works, have been burning natural gas or producer gas. Pulverized coal has lately been given a trial on some of such furnaces also.

The main difficulty in the practical application of pulverized coal firing has been encountered in developing machinery suitable for pulverizing the coal and mixing it evenly with air to form the necessary blast. To burn powdered coal successfully, it must be burned while in suspension in the air. For this reason, the coal must be ground very fine, since the time of combustion is evidently increased as the size of the coal particle is increased. The finer, therefore, the grinding, the more perfect the combustion.

It should, in this connection, be kept in mind, that, in some cases, failures of powdered coal installations have been blamed on the fuel, while they actually were due to the furnace in which the pulverized coal was used. It must be emphatically stated, that a furnace must be built for the fuel which is intended to be applied, it being a serious mistake to attempt to apply powdered coal to existing furnaces without rebuilding them and making them suitable for that new fuel. Another reason for failure lies in the fact that with some arrangements the powdered coal is admitted to the furnaces in too wet a state. The moisture contents should not be above .5 per cent; care must be taken in drying not to overheat the coal and thus drive off some of the valuable volatile constituents. The coal should, for ordinary conditions, be pulverized to a fineness to permit 95 per cent to go through a 100-mesh sieve, while for some special cases of work a greater fineness may be required, but it hardly will be necessary to exceed a fineness which permits 85 per cent to go through a 200-mesh sieve.

Producer gas can, in many cases, be applied directly in place of natural gas, as many of the furnaces built during the last year, have been provided for the use of the fuel in question, although at the time of erection and for some time afterward they were to be used for natural gas. In such a case the regenerative chambers are built for gas and air in sizes suitable for producer gas, but they are only partly used for preheating the air. Natural gas cannot be preheated, because the hydrocarbons, amounting to about 95 per cent of the gas, would become decomposed. Since the amount of air required for the combustion of one cubic foot of natural gas is about 10.

times that required for the combustion of one cubic foot of producer gas, and since we have to use about seven cubic feet of producer gas to every cubic foot of natural gas, the chambers provided for preheating the producer gas are big enough to preheat the air as long as natural gas is used. After the fuel is changed the other chambers will be opened and used for the air, while the former air chambers are used for preheating the producer gas. (In many cases, however, both regenerating chambers are used for the air, as long as the furnaces are fired with natural gas.)

The furnace proper does not have to be changed at all, because the combustion space needed is for both fuels practically the same. One cubic foot of natural gas gives approximately 16 cubic feet of (wet) products of combustion, while the corresponding figures for producer gas is about 2.2 cubic feet. But, since one cubic foot of natural gas is equivalent to seven cubic feet of producer gas, the corresponding quantity of waste gases from producer gas is $7 \times 2.2 = 15.4$ cubic feet, or practically the same as that for natural gas.

It is true, producer gas can not as easily be handled as natural gas, since the latter, being nature's gift, is the most ideal fuel in existence. But this difficulty can be overcome by a careful control of the producers as well as the furnaces and the flues by suitable instruments, such as gas analyzers, pressure and volume gauges or meters, and pyrometers, and there is no reason whatever, that after a producer gas plant has been in operation for a comparatively short time, it should prove defective or unsatisfactory, provided it is at all fit for the purpose it is used for.

In regard to the advantages or disadvantages of one system over the other one, the following may be stated furthermore:

A fuel oil installation can be made on short notice, but it involves changes in the furnaces; it has the further disadvantage, that the cost of the fuel is high, thus increasing the cost of operation considerably, notwithstanding a low first cost.

A powdered coal installation requires more or less complicated machinery, the manufacture of which will take time, since it hardly will be kept in stock, the demand for this type of fuel utilization not being very heavy. This means a shut down of the plant as soon as the natural gas supply is turned off, if the apparatus was not ordered in time, and such a shut down means a loss in production. The installation must be made in such a way, that the pulverized coal is practically moisture-free, since, if this is not the case, trouble will result in the operation. An advantage of this type is the low cost of the fuel compared with that for oil, reducing the cost of operation, thus even counterbalancing the high first cost, as will be shown below. It is, however, necessary to use a coal for pulverizing which does not contain less than about 28 per cent volatile matter and not more than 10 per cent ash. It is furthermore difficult—at

least in some types of these apparatus—to have the coal supplied uniformly to the burners, to insure a uniform heat.

The successful application of powdered coal to small furnaces has been proven beyond doubt, if only the pulverizing and conveying plant and the burners were designed along scientific principles; but installations for large furnaces have not been in operation long enough and extensively enough to prove their value, at least in the United States.

If natural gas had been used as fuel prior to the application of powdered coal, the furnaces must be changed to suit the new conditions, as was the case for oil.

If producer gas is supposed to be used as a substitute for natural gas, the furnaces can remain unchanged, if they have provisions for the preheating of the fuel. If this is not the case, additional regenerating chambers must be provided, while the other parts of the furnace can remain as they are, assuming, of course, that they are in a good condition. In regard to the quickness of installation, the same must be said as for powdered coal, viz.: it will take some time, until the producers will be delivered, although, at present, the demand for gas producers is high, and, for this reason, there will likely be some manufacturers, who have the material for suitable gas producers in stock.

Producer gas installations have been in successful operation in many plants, small ones as well as large ones, and wherever they failed, it was or is either due to ignorance on the part of the operators or to the unsuitability of the fuel or the apparatus for the purpose in question.

If a comparative calculation of the cost of operation of the different systems is to be made, this can be done by referring it to a common base. Supposing a plant is using 1,500,000 cubic feet of natural gas per day of 24 hours, operating 300 days in a year; what will be the cost of installing and operating each one of the three fuel plants in question, everyone being of such a size as to supply an amount of fuel equivalent to the above given 1,500,000 cubic feet of natural gas?

One million five hundred thousand cubic feet of natural gas per day correspond to $1,500,000/10$ or 150,000 pounds of coal per day—figuring on a coal with 14,000 B.t.u. and on a conversion efficiency of 70 per cent—or 75 tons of coal per day. This amount is necessary for the producer gas plant. Taking the heat value of one gallon of crude oil as 140,000 B.t.u., the ratio of oil to coal is again 10 to 1, giving 15,000 gallons of fuel oil per day. For the powdered coal plant we need about 20 per cent less coal than for the gas producer plant, thus reducing this figure to 60 tons per day.

Based on these data, the calculation will have the following result:

To have one week's supply of oil on hand, nine tanks are required, holding 10,000 gallons each.

For the first cost of a fuel oil plant:

Cost of Fuel Oil Installation.	
9 10,000-gallon storage tanks at \$1,500 each...	\$ 13,500
Foundations, erection, etc.	5,500
6 Auxiliary pressure tanks, complete	9,000
3 Circulating pumps and motors	900
Piping, valves, fittings, steam and air connections, etc.	20,000
90 Connections to furnaces at \$70 each.....	6,300
Standpipes for tank cars	800
Pumps and other appliances, blowers, motor and blast connections	20,000
Total	\$ 76,000

For the powdered coal plant we have (see previous page) a coal consumption of 60 tons per day. The first cost will be:

Cost of Powdered Coal Plant.	
Pulverizing machinery	\$ 60,000
Buildings and foundations	20,000
Coal handling and conveying	15,000
Flues and valves	12,500
Blowers, motors, etc.	20,000
Exhaust, etc.	15,000
Total	\$242,500

Say \$243,000 for the powdered coal plant.

For the producer gas plant we have to gasify 75 tons of coal per day, or 150,000 pounds of coal per day, corresponding to 6,250 pounds of coal per hour. Figuring on a capacity of 1,250 pounds of coal per producer per hour, we need five producers and one for spare.

Cost of Gas Producer Plant.	
6 10-foot producers	\$ 24,000
Buildings, foundations, excavating, erection, freight, etc	18,000
Coal handling and crushing	6,000
Coal bunkers	6,500
Foundation for coal handling machinery	3,000
Steam and water piping along producers	5,000
Overhead flues, valves and stacks	16,000
Total	\$ 78,500

Say \$80,000 for the gas producer installation.

The operating cost per day includes the fixed charges and the cost for operation. For this calculation the "day" has been taken as a unit, because the corresponding figures for a year or even a month would be too large, on account of the large fuel consumption. The figures for a day are short and can easily be overseen.

Operating Cost for Fuel Oil Plant.

	Per day
Interest, depreciation, taxes, 16 per cent of \$76,000	\$ 40.53
Fuel oil, at 6 cents a gallon, .06 × 15,000.....	900.00
Labor, 16 men for two shifts at 35 cents per hour	67.20
One foreman	5.00
Electric current, air and steam	6.00
Lubricating oil, waste, etc.	.75
Total	\$1,019.38

Operating Cost for Powdered Coal Plant.

	Per day
Interest, depreciation, taxes, 16 per cent of \$243,000	\$ 129.60
Coal, 60 tons per day at \$3	180.00
Unloading coal	2.00
Electrical current, air, etc.	15.00
One foreman	5.00
Labor, 16 men for two shifts at 35 cents per hour	67.20
Lubricating oil, waste, etc.	1.00
Total	\$ 399.80

Operating Cost for Producer Gas Plant.

	Per day
Interest, depreciation, taxes, 16 per cent of \$80,000	\$ 42.67
Coal, 75 tons per day at \$3	225.00
Unloading coal	2.25
One foreman	5.00
Labor, 10 producer men for two shifts, at 35 cents per hour	42.00
Two ash men, \$3 per day	6.00
Steam and water	6.00
Total	\$ 328.92

(Continued on Page 180.)

Selection of Steel Mill Auxiliary Motors

Describing Functions, Mechanical Layout and Operation of Manipulators for Blooming Mills—Conclusions as to Size of Motors and Control Most Suitable for Driving These Auxiliaries.

By J. D. WRIGHT.

Usually the first questions which one is likely to ask when considering the proper type of motor and control for any steel mill auxiliary machine, are, "What is its function; what is the mechanical layout, and how does the device operate?" Without a thorough knowledge of the answers to these questions one is unable to make an intelligent recommendation on the application of either motors or control.

* Abstract of paper presented before joint meeting of A. I. E. E. and A. I. S. E. E., Cleveland, O., March 8, 1918.

It is, therefore, the purpose of this article briefly to describe a few steel mill auxiliary machines with particular reference to their mechanical details.

Manipulators for blooming mills consist of side guards and lifting fingers. The function of the former is to guide the bloom into the proper groove in the rolls while the latter are used for turning the bloom over.

A reversing mill is usually provided with four moving side guards, two on each side of the mill, one guard on the side of the mill with the operator's

pulpit being provided with the lifting fingers. Occasionally a set of lifting fingers is provided on each side of the mill, but as the bloom is usually turned only on the pulpit side, fingers are more commonly provided only on that side.

Fig. 1 is a general view of the entering side of a reversing blooming mill equipped with electrically operated manipulators. The two side guards are clearly shown and, on close inspection, the lifting fingers may be seen just inside the left hand guard.

Each side guard on the entering side of the mill is connected by suitable mechanical means to the cor-

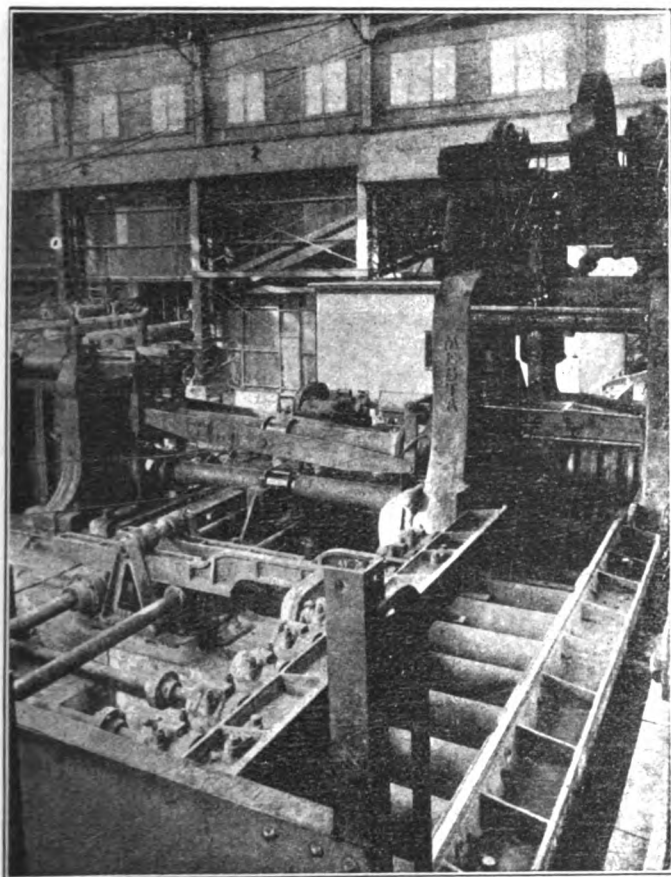


Fig. 1—Blooming mill with electrically-operated manipulators.

responding guard on the delivery side, so that the right hand and left hand guards on opposite sides of the mill always have the same movement and are always in line.

One method of mechanical connection between the motors and the side guards is as follows: Two motors, one on each side of the mill, are geared through slip clutches to a common shaft on which are mounted four pinions which engage with four racks. Two of the racks are attached to one guard on the entering side and the other two to the corresponding guard on the delivery side of the mill.

The remaining two guards on opposite sides of the mill are similarly operated by a second pair of motors. The racks are supported by rollers and me-

chanical stops are provided to limit their outward movement.

As previously stated, the function of the side guards is to guide the bloom into the proper groove in the rolls. The operation of the guards during the process of rolling an ingot consists, therefore, of many fast, short movements back and forth across the table. Each guard on one side of the mill can move independently of the other and can make a stroke equal to the width of the table. It is possible, therefore, for the guards when moving inward to come together or against the ingot at full speed. It is the function of the slip clutch to prevent damage as a result of such action should the operator be careless enough to allow it to occur.

The motor equipment for the side guards consists of four 80-hp series motors, two connected in series driving each pair of guards. Satisfactory operation of the guards requires rapid acceleration and retardation, and for such service series motors are most desirable. Some installations, however, use compound wound motors, primarily because dynamic braking for

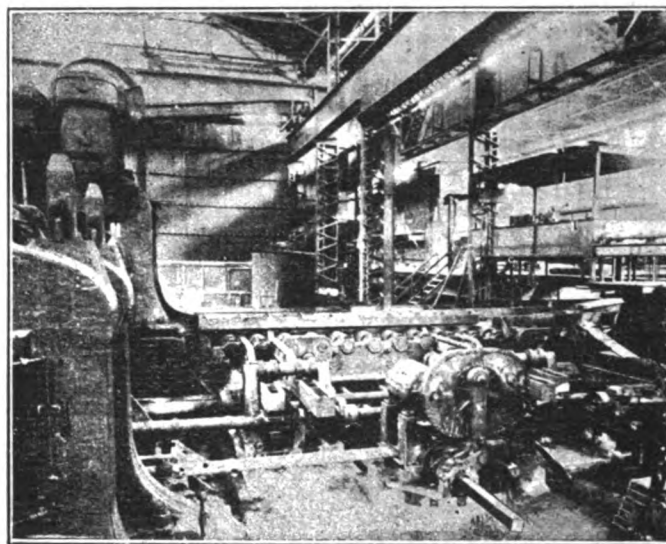


Fig. 2—View of blooming mill with electrically-operated manipulator fingers and side guards.

stopping was desired. Furthermore, solenoid brakes are sometimes used to assist the dynamic braking. In the equipment illustrated, neither dynamic braking nor solenoid brakes are used. When a quick stop is desired the motors are plugged. The equipment is therefore extremely simple.

The control for each pair of motors is, of course, reversible and is arranged so that a bank of resistance is permanently connected in series with the motor armatures. This acts as a buffer and reduces the shock when the guards jam together or against the ingot. A one-point reversible master controller is used for each pair of motors. Limit switches are provided for cutting off power when the side guards are moved to the edge of the table. These limit

switches are usually of the track type and are operated by movement of the rack. A geared switch might be used but the track type switch is much simpler and more positive in action.

The lifting fingers, which are used for turning the bloom over, are carried by a frame attached to the two inside racks connected to one of the side guards. They therefore move back and forth with the guard. The fingers are located just inside the guard and their lower ends are pinned to a yoke which is suspended from two horizontal shafts by means of two links and levers. The two horizontal shafts, which are supported by bearings in the finger frame, are connected through cranks to a common driving shaft. On this shaft is mounted a large gear to which the two driving motors are geared. It is evident that one-half revolution of the main driving shaft in either direction will produce a complete upstroke of the lifting fingers. Another one-half revolution would produce a complete downstroke and return the fingers to their original position.

The motors may, therefore, be either reversible or non-reversible. Successful installations of each have been made. When a non-reversing equipment is used, one complete cycle consists of an up and downstroke of the fingers. When a reversing equipment is used forward direction of rotation may produce the upstroke and reverse rotation the downstroke.

The motor equipment illustrated in Fig. 2 consists of two 50-hp series motors connected in series, operating non-reversing. For each throw of the operator's master controller a complete up and downstroke of the fingers is produced. The motors are automatically stopped at the end of the downstroke by a limit switch which cuts off power and completes a dynamic braking circuit.

The dynamic braking connections for a series mo-

tor operating non-reversing are comparatively simple. Where reversible control is used, a compound wound motor is preferable if dynamic braking is desired, as the control connections are simplified. Solenoid brakes are required if the equipment is reversible, whereas if non-reversible, no brakes are necessary. It has at times been stated that the operator should be able to control the stroke of the fingers. This, of course, necessitates the use of reversible control, but the movement of the fingers is so rapid that it very frequently happens that the fingers make a complete upstroke before the operator throws his master controller to the reverse position to lower them.

It has been shown that for the side guards a reversible equipment must always be provided. The motors may, however, be either series or compound wound. Dynamic braking and solenoid brakes may or may not be used. The operator's master controller may be one-point reversible or multi-point reversible. Track type limit switches or geared limit switches to limit the movement of the side guards may be used.

For the lifting fingers it has been shown that the equipment may be either reversible or non-reversible. The motors may be either series or compound wound. Dynamic braking and solenoid brakes may or may not be used. The operator's master controller may be one-point or multi-point reversible or non-reversible. The limit switch may be arranged to stop the motors when the fingers are at the end of their downstroke if the control is non-reversible, and if reversible the limit switch may be used to stop the motors with the fingers in both up and down positions.

There must, however, be one method of operating these devices which is superior to all others. What this method may be can be determined only from actual operating experience, and it is to the steel mill electrical engineers that we must look for the results of such experience.

Elements of Roll Pass Design

Explaining the Proper Design of Edging Passes for Angle Blanks and the Greatest Permissible Bending from the Butterfly Shape to the Finished Angle.

By W. TRINKS.

The difficulties of collapsing or buckling and of insufficient traction, encountered in the edging of a beam blank were explained in the March issue of this journal. The problem which will be solved in the present installment, and which bears directly on that difficulty, is that of investigating the deformation which takes place in the edging pass of an angle blank. It will be seen from what follows, that this case involves one more variable than those which were analyzed in previous articles. Heretofore we had to

decide, as the stock moved forward in the pass, what fraction of the deformation went into elongation, and what fraction went into spreading. In the present case we shall, in addition, have to decide what part of the deformation goes into buckling or bending.

At this point it is desirable to explain more fully the three kinds of deformation here considered. While a bar passes through the rolls, the latter close in more and more on a given cross-section, thus compressing the material. If the pass is closed, and is filled by

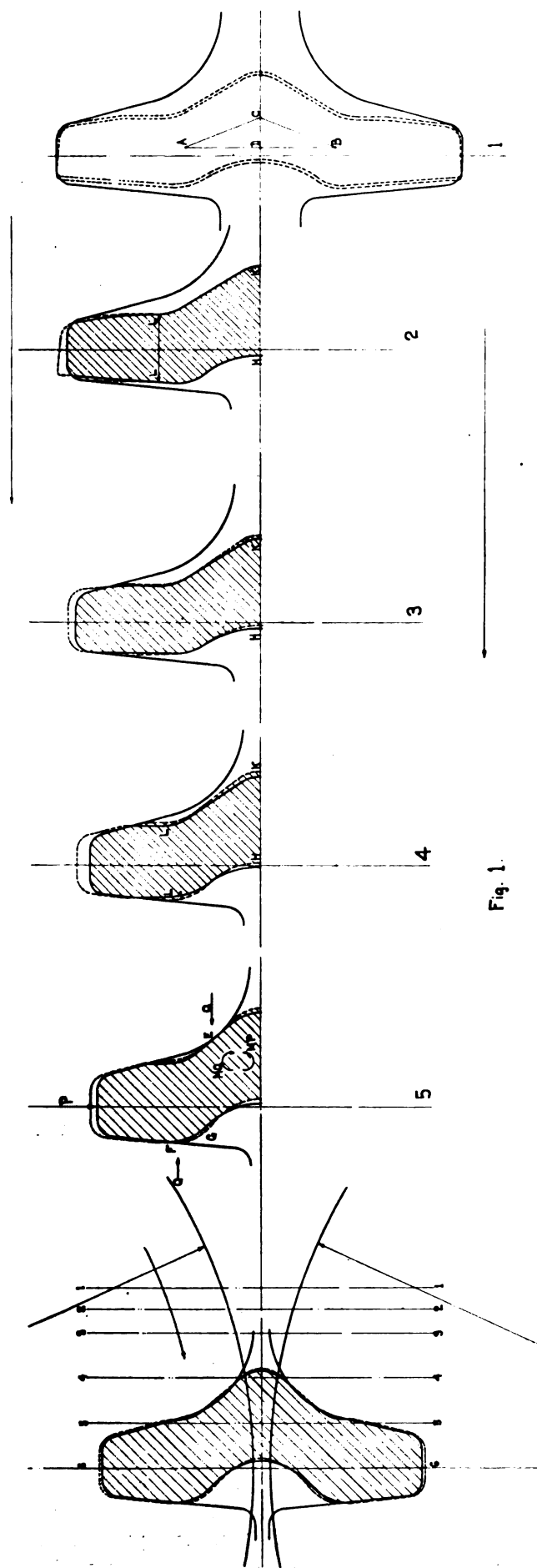


Fig. 1.

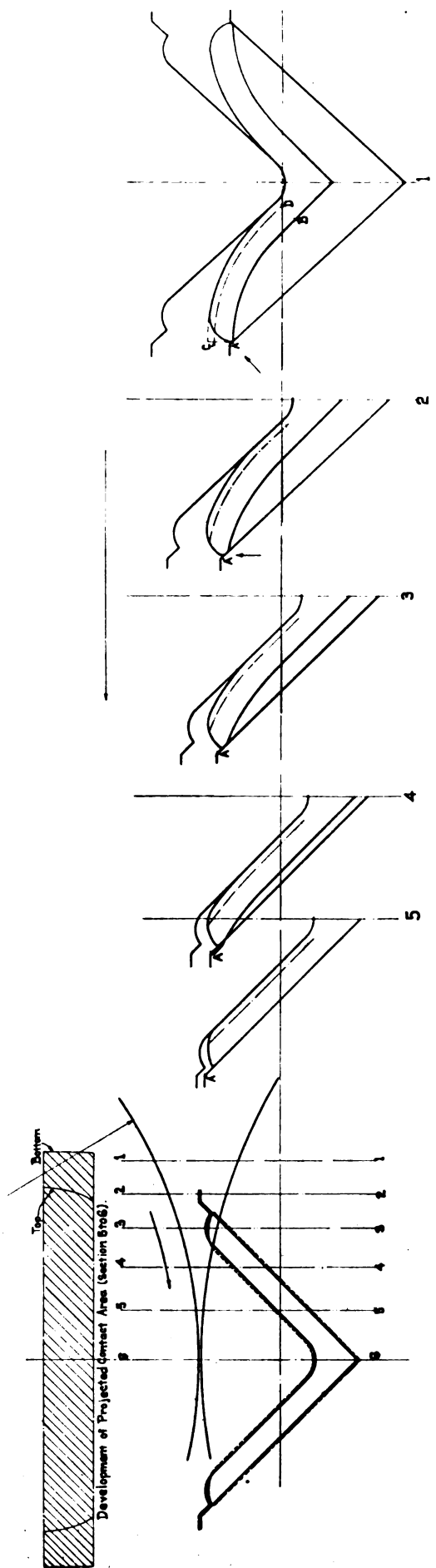


Fig. 2.

Fig. 1—Analysis of edging pass for angle blank. Fig. 2—Analysis of finishing pass in butterfly method of rolling angles.

the material, all of the area which is displaced by the approach of the rolls must go into length. If the pass is open and is of such shape that it can transmit compressive stress from roll to roll without bending, then part of the displaced area of the cross-section goes into elongation, while part of it goes into spreading. This means that while the approach of the rolls reduces the cross-section, the spreading partly counterbalances the reduction. If, finally, the section is such that it can collapse in the pass, then we can imagine the extreme case of change of shape of section only, neither elongation nor spreading being caused by the approach of the rolls.

Fig. 1 shows the gradual deformation of the blank in the edging pass. The analysis is in every way similar to that carried out in previous articles. Sections were taken at regular intervals, at right angles to the stock, on the entering side of the pass. They are numbered from 1 to 6, going from right to left. Between sections 1 and 2 the rolls are just taking hold. At first, contact takes place in a few corners, which means that the pressure is local; it is concentrated on small spots which have to bear a much higher unit stress than the rest of the material. The elastic limit is exceeded in spots only, and deformation is local. This condition does not exist long, but the conditions are very favorable to lateral local spreading from sections 1 to 2. For that reason it is probable that about two-thirds of the total displaced area will go into lateral spreading, and that only about one-third will go into elongation.

Between sections 2 and 3, spreading cannot occur as freely as it did between sections 1 and 2, because the steel touches the sides of the groove. This condition would produce considerable elongation, if it were not for the buckling of the section. It is evident that the compressive stress will be quite intense at point H, sections 2 and 3, while there may even be slight tension (up and down) at point K. Assuming the material to be perfectly plastic, we find the compressive stress at H to be almost $2\frac{1}{2}$ times as great (see appendix) as it is at LL. Forward motion is still difficult. It is, therefore, probable that only one-third of the displaced area goes into elongation, while one-half of the remaining area goes into spreading, as indicated, and while the other half of the remaining compression height decreases distance AB, increasing distance CD a corresponding amount.

The same relations exist more or less between sections 3 and 4. The wedge-shaped grip of the rolls extends so far down, and the collapsing action is so great, that only a small fraction of the total deformation can go into elongation, while its greatest part consists in collapsing. Between sections 3 and 4 the compressive stress at H is approximately four times as great (see appendix) as the compressive stress in the section LL. Consequently, the probable shape of the stock in section 4 was sketched on the basis

of 25 per cent of the displaced area going into elongation, 25 per cent going into lateral spreading, and 50 per cent being accounted for by collapsing or buckling. In section 4 this latter action has almost reached its greatest intensity.

Further intensification of this action is checked by the steel's coming in contact with the rolls at point E (see section 5). This contact occurs somewhere between sections 4 and 5. The immediate effect of this contact is the setting up of a couple counteracting the bending caused by the bending force P. Study of the upper half of section 5 shows that the moment MP caused by P turns counterclockwise, while the moment MQ caused by the forces Q at E and F turn clockwise, the result is that the bending or buckling effect of P is greatly diminished. Allowing for the circumstance that, in section 4, the steel

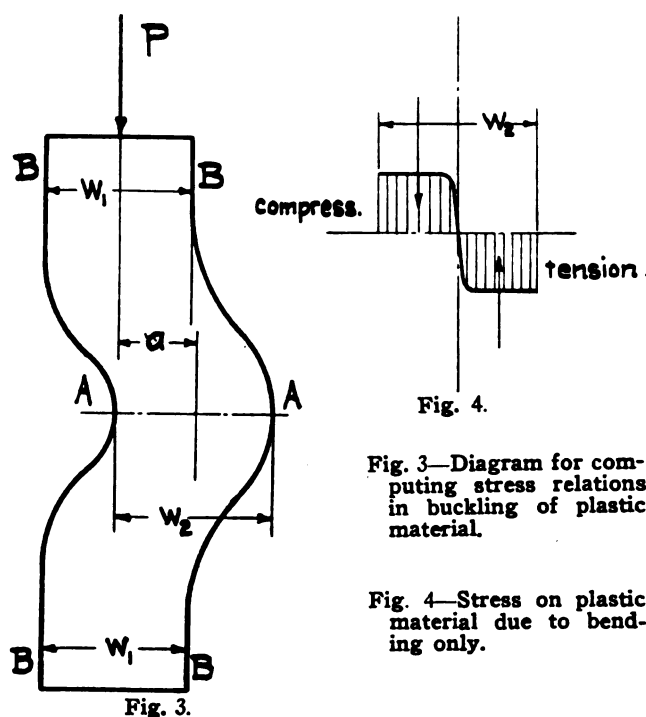


Fig. 3—Diagram for computing stress relations in buckling of plastic material.

Fig. 4—Stress on plastic material due to bending only.

has not yet touched the rolls at E, and in consideration of the fact that the shape in section 5 must be the result of all forces acting between 4 and 5, one-third of the displaced area was assumed to go into elongation, one-quarter is accounted for by bending, while the rest goes into spreading, which, of course, means growth of cross-section counteracting the reduction of area which is caused by the approach of the roll surfaces. Spreading occurs to the greatest extent, where the forces favoring it find least resistance. In the section under discussion that place is G.

Very much the same reasoning applies between section 5 and the final section 6, except that the total friction resisting forward motion is now very small. But the resistance to spreading at G is likewise exceedingly small, while further collapsing is almost impossible. In consequence, section 6 was laid out

on the basis of one-half the deformation going into length, and the other half going into spreading, mostly at G.

The second problem of interest concerning angles which will now be taken up is that of bending an angle from the butterfly shape into the final straight-leg shape. The "schedule of events" is shown in Fig. 2. As before, the bar moves from right to left. Sections were again made through the roll and through the angle to investigate the gradual process of deformation. Section 1 shows the angle as it comes from the preceding pass. It is shown as touching both top and bottom rolls. This need not necessarily occur, because the guide may, and probably will, enter the angle so that the latter touches one of the rolls ahead of the other. However, that makes very little difference, because the roll which comes in contact first will soon deflect the whole bar so that it also touches the other roll.

Fig. 2 shows that from sections 1 to 5 there is practically no compression. All deformation is caused by bending within that range.

Point A in sections 1 to 4 denotes the point where the entering section first touches. From a study of the drawing it is evident that a sliding action takes place between the tips of the angles and the rolls. This sliding has several effects. First, it wears one of the rolls over the range marked with heavy black in section 4; second, it sharpens the corner at the tip of the angle; third, it increases the tension which is produced by bending up the angle. If the bending force were applied in the direction of the arrow at A, section 1, then the neutral axis would lie in the center of the width of the angle; but since the force is applied, as indicated by the arrow at A, section 2, the neutral axis is shifted to about one-quarter of the thickness from the inner edge. The amount of elongation which results from the bending up can, therefore, be quickly ascertained by measuring the distances AB and CD (see section 1). Then $\frac{CD - AB}{AB}$ is

the unit or specific elongation which results from the bending up. A perfectly plastic material will stand a single (not repeated) elongation of 100 per cent if lateral contraction is prevented, and will stand much greater elongation if lateral contraction is permitted. In the present case the unit elongation is about 10 per cent, with lateral contraction prevented. Consequently no cracks need be feared, either with steel or wrought iron. If the unit elongation by direct tension across the slag grain exceeds 15 per cent in wrought iron, cracks are likely to appear. There is nothing particularly definite about the 15 per cent, because the nature and extent of the slag enclosure modifies the limiting elongation. With steel, a greater amount of bending up than here shown is permissible; the

limit is set by other reasons, particularly by wear of rolls.

A different action begins just as soon as the angle touches both rolls the whole length. The regular compression and elongation which forms the object of all rolling processes takes place between sections 5 and 6. The amount of compression in the finishing pass is usually very small, so as not to destroy the accuracy of the final pass. A slight compression is desirable, because it counteracts, to a certain extent, the loosening influence of the tension caused by the bending up process. The amount of lateral spreading which occurs in this pass is of interest. Above section 6 a development of the projected contact area has been shown. It is somewhat different for the top and bottom rolls. The contact area then is a rectangle of ratio of sides of about eight to one, which means that less than one-tenth of the displaced area will go into spreading. The pass, therefore, barely fills. No fin will be produced.

Appendix.

Buckling depends upon the pressure distribution in section AA, Fig. 3. To determine it, let P be the force per inch of length (the latter measured at right angles to the paper) acting in the center of width w_1 (see Fig. 3). Then compressive stress in sections BB is $\frac{P}{w_2}$. The stress in AA is partly caused by direct compression and partly by bending. The direct compressive stress is $\frac{P}{w_2}$. The bending stress cannot be found by the commonly used formula, because all of the fibers (with the exception of an exceedingly narrow strip) are strained beyond the elastic limit. Hence the pressure distribution is of the character indicated in Fig. 4. Let p be the bending stress, then, by a moment equation

$$P a = \frac{1}{2} w_2 p \times \frac{1}{2} w_2 = \frac{1}{4} p w_2^2.$$

The maximum compressive stress then is

$$\frac{P}{w_2} + \frac{P a}{\frac{1}{4} w_2^2} = \frac{P}{w_2} \left[1 + \frac{49}{w_2} \right]$$

Of course, this stress can never exceed the elastic limit by very much, because deformation begins at the elastic limit. From that standpoint the equation just given looks foolish and impossible. The equation

has, however, the meaning that, if $\frac{1}{w_2} \left[1 + \frac{49}{w_2} \right]$ is

greater than $\frac{1}{w_1}$, that deformation will begin at AA

before it will begin at BB. If, on the other hand, $\frac{1}{w_1}$ is greater than $\frac{1}{w_2} \left[1 + \frac{49}{w_2} \right]$, then deformation will begin at BB, before it will begin at AA. Deformation will occur also at AA at the same time, however, but at a slower rate, and hence with a lower stress.

Modern Condenser Practice Considerations

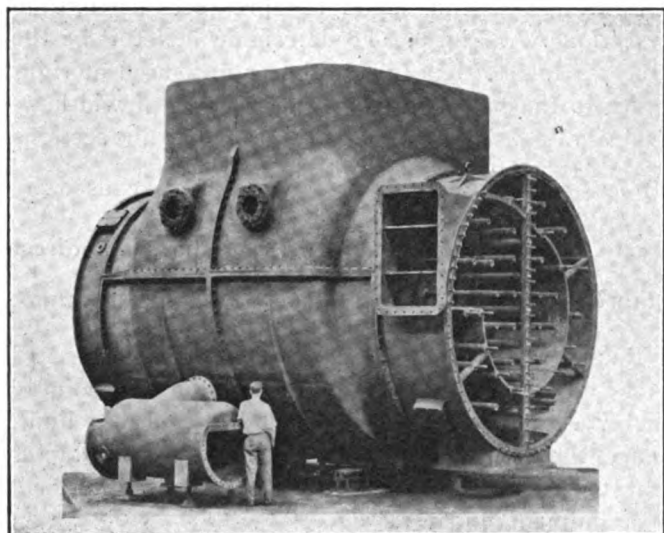
Choice of Condenser—Classification of Types and Their Limitations—Auxiliaries—Data Presented in Tables—Curves of Pump Test—Artificial Cooling of Water by Means of Cooling Towers.

By D. D. PENDLETON.

The types of condensers are surface, jet and barometric. For high-duty work, 28-inch vacuum or better, the type of condenser to be selected should be thoroughly studied, taking into consideration the engineering, physical and commercial conditions, and particularly the question of water with respect to:

1. Quantity;
2. Quality (clean, dirty, acid, etc., or suitability for boiler-feed purposes);
3. Pumping head;
4. Source (natural or artificial);
5. Average temperature.

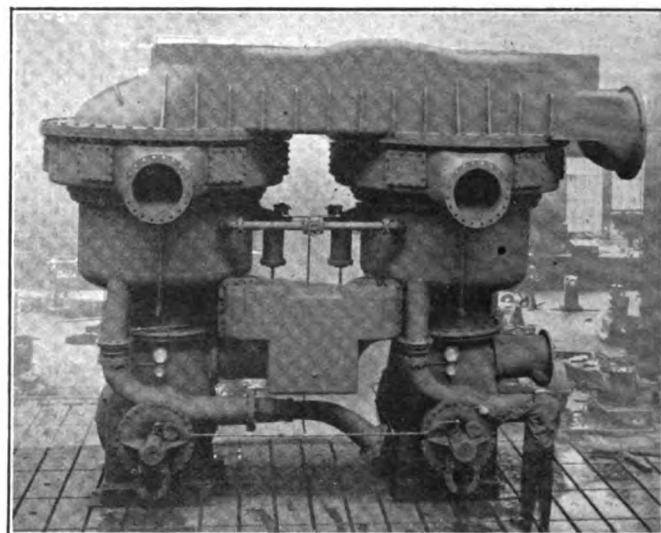
In some localities the choice of type is determined by a practice of long standing, by certain prejudices, or by failure to properly investigate all phases of the situation. Pittsburgh and vicinity had for a long time the "barometric habit," so to speak, this perhaps being due principally to the fact that the manufacturers of mill equipment, who usually furnished complete equipment of engines, condensers, etc., in a great many cases had only the barometric to offer. Later the low type or centrifugal jet condenser appeared and was advocated for the same reason, the surface con-



Fifty thousand square foot surface condenser, showing water outlet nozzle, tube plate and four-pass internal heater.

From a consideration of these points may be determined the commercial vacuum which it is practicable to maintain, always bearing in mind that the average log of a properly designed, rated and operated surface condenser will show a better vacuum than a jet machine, and the latter in turn better than a barometric machine, due principally to the conditions as to air leaks, air to be handled by air pump and exhaust piping losses. The surface machine also enables the condensate to be reclaimed in the shape of pure distilled water for boiler feed, thus requiring only a moderate amount of make-up water to be treated or purchased in cases of unsuitable boiler-feed supply.

A paper presented before the Engineers' Society of Western Pennsylvania. The author is district sales manager of the Wheeler Condenser & Engineering Co., Pittsburgh.



Twin low-head jet condenser for 20,000 kw. turbine, twin tail pumps and twin air pumps.

denser usually being condemned without a hearing. Now the operating engineers are seriously studying their own problems, and in most cases using the type best suited to their conditions. After considering all the possible conditions which have been mentioned above, and which should apply to each individual case, the choice of a condenser should be made according to the power requirements and operating cost in connection with the existing conditions.

Assume a case of 40,000 pounds of steam per hour, 28-inch vacuum, based on 30-inch barometer, and temperature of water 70 deg. F. The power requirements under these conditions will be as follows:

Surface.

The water required for a surface condenser is usually based on 15 deg. difference, and for this case

would require 5,000 gallons per minute. Since the discharge should be sealed in order to obtain the benefit of the siphon effect, a head of 10 feet should be ample under ordinary circumstances. This would require a water hp of 12.5, and with an efficiency of 75 per cent on the centrifugal pump, a total pumping hp of 16.66 would be required.

Using the wet and dry system the air pump would require approximately 6 hp and the condensate pump about $2\frac{1}{2}$ hp, or a total of approximately 25 hp. If a turbo air and condensate pump were used, 40 hp would be required, making a total of approximately 56.66 hp.

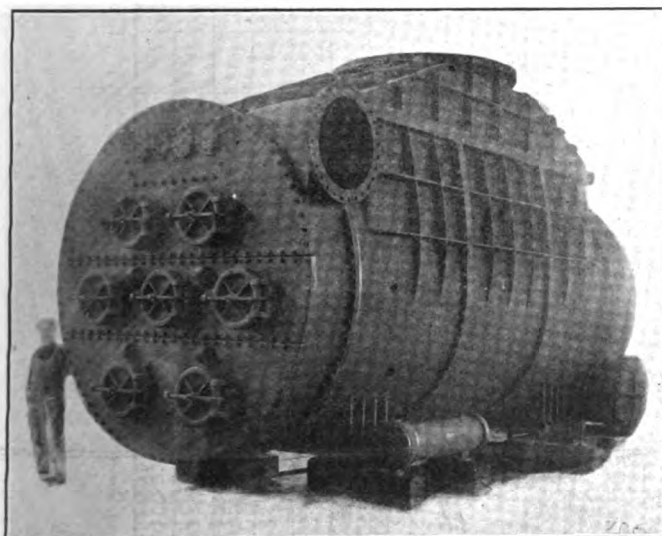
Low-Type Jet.

The water requirements of the low-type jet condenser can be figured at a temperature difference of 5 deg. This will require less water than the surface condenser, or 3,100 gallons per minute. The efficiency of the tail pump or removal pump on any jet condenser

be lifted to the condenser head against the total static head, from which may be subtracted the suction effect of the vacuum. With the source of the water at approximately the same level as the hot-well discharge the net head on the barometric can be considered at 30 feet, making a total of 23.25 water hp. The efficiency of the supply pump should be at least 70 per cent, making a total of 33 hp for same. The air pump being the same as for the jet, namely, 12 hp for the reciprocating, direct-acting pump and 55 hp for the turbo air pump, would make the totals 45 and 88 hp, respectively. The steam jet in place of the above-mentioned air pump would materially increase the air removal power requirements.

From these cases we have:

1. Surface—25 hp with direct-acting, reciprocating air pump and centrifugal hot-well pump; or 57 hp with the turbo air pump.



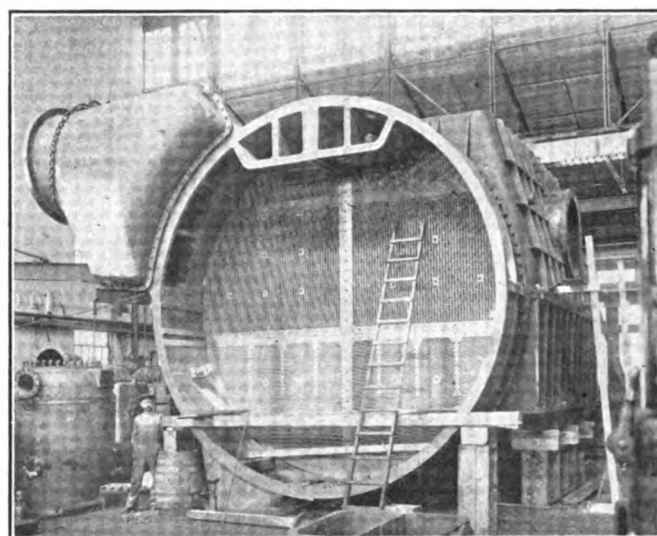
Twenty-five thousand square foot surface condenser, three-pass type for 5-degree difference for use with cooling tower—One hundred square foot standard surface condenser.

should not be figured at more than 50 per cent. In some cases it has been known to go as high as 60 or 65 per cent. This, however, is extreme. A total pumping head of 36 feet is usually figured, this being the discharge head from the condenser, plus friction at the tail pump nozzle, which in this case would require approximately 27.9 water hp. At 50 per cent efficiency a total of 55.8 hp would be required for the removal pump alone.

The direct-acting, reciprocating air pump would be twice as large as for the surface condenser and would require, say, 12 hp, making a total of 68 hp for the jet system. If a turbo air pump were used, 55 hp would be required, instead of 12 for the reciprocating pump, making a total of 111 hp.

Barometric.

The barometric condenser will require the same amount of water as the jet type, but the water may



Fifty thousand square foot surface condenser—Special water box 500 square foot surface condenser.

2. Barometric—45 hp using direct-acting, reciprocating air pump; or 88 hp with turbo air pump.

3. Low-type jet—68 hp using direct-acting, reciprocating air pump; or 111 hp using the turbo air pump.

Limitations as to Types.

There is no limit to the size of surface equipments—they are now being made in sizes from 100 square feet up to 70,000 square feet.

The barometric is quite limited owing to the expensive and almost impossible exhaust piping for large units.

The low-level jet is also quite limited as to size, this being due to the removal or tail pump and air pump limitations and the power for driving the same. The practical limit for these two types seems to be 7,500 to 10,000 kw, although there have been installed in certain cases twin jets on machines up to 45,000 kw. This was not through any engineering or practical

condition, but principally a matter of personal preference business policy, or possibly of first cost, certainly not from an engineering standpoint.

For instance, a 20,000 kw turbine at 12.5 pounds per hp-hour, or 25,000 pounds of steam, would require at 15 deg. difference for surface work 31,250 gallons of water per minute at 70 deg. water and 28-inch vacuum, against a 10-foot head. This would require approximately 100 hp.

The air and condensate pump of the hydraulic type requires 140 hp additional, or a total of 240 hp with one set of auxiliaries only. These can be duplicated, using one set as spare auxiliary equipment. If the wet and dry system be used the air pump and conden-

and it is in most cases doubtful if the overall efficiency will justify this extra cost.

It should also be borne in mind that a turbine should be specially designed as to the low pressure blading, so as to handle without undue throttling the enormous volumes of steam due to the high vacuum. If not so designed a back pressure is set up in the low pressure stages, thus defeating the results even though the condenser be designed for that specific duty. The failure to maintain specified overall duty is in most cases blamed on the condenser.

Auxiliaries.

After fixing the type of condenser to be used the

		GALLONS PER MINUTE OF CIRCULATING WATER AND SQUARE FEET OF SURFACE FOR 1,000,000 B.T.U. PER HOUR (1,000 LBS. OF STEAM, 1,000 B.T.U. PER POUND)																											
VACUUM PERMITTED IN A 24 HOUR PERIOD	DIFFERENCE BETWEEN CONDENSER AND SURFACE WATER TEM. DEG. F.	TEMPERATURE OF ENTERING WATER																											
		40°		45°		50°		55°		60°		65°		70°		75°		80°		85°		90°		95°		100°			
		GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.	GPM	SQ. FT.
29"	20	105	113	142	153	221	136	492	151	492	196	377	492	474															
	15	83	123	103	136	142	151	221	171	492	196	377	492	474															
	10	69	134	83	151	103	171	142	196	221	230	402	277	350	492	474													
	5	50	151	69	171	83	196	103	230	142	277	221	350	492	474														
28"	20	77	101	96	110	126	119	164	131	342	145	186	342	250															
	15	65	110	77	110	96	131	126	145	166	163	342	186	250															
	10	56	119	65	131	77	145	96	163	124	186	186	250	342	250														
	5	49	131	56	145	65	163	77	186	96	250	250	342	492	474														
28 1/2"	20	63	99	74	100	81	108	118	117	163	120	240	142	159															
	15	54	106	63	106	74	117	91	158	118	142	168	159	240	181														
	10	48	106	54	117	63	120	74	142	91	158	168	240	290	248														
	5	43	117	48	120	54	142	63	159	74	161	91	209	118	243	160	394	290	304										
28"	20	55	87	63	93	73	99	92	108	119	118	129	237	143															
	15	48	93	55	99	63	108	73	118	92	129	119	143	170	160	297	182	297	249										
	10	43	99	48	108	55	118	63	126	73	143	92	160	119	182	170	210	297	249										
	5	39	108	43	118	48	126	55	143	63	160	73	182	92	210	119	249	170	306	297	306								
28"	20	49	82	55	88	64	94	77	101	93	109	124	118	120	130	323	143												
	15	43	88	49	94	55	101	64	109	77	119	93	130	124	143	179	162	323	184										
	10	39	94	43	99	49	109	55	119	64	130	77	143	93	162	124	184	179	214	323	233								
	5	36	101	39	109	43	119	49	130	55	143	64	162	77	184	93	214	124	253	179	313	323	412						
27 1/2"	20	41	75	46	80	52	85	59	90	70	97	83	104	107	114	146	124	230	137	340	160								
	15	37	80	41	85	46	90	52	97	59	104	70	114	83	124	107	137	146	160	340	172	340	186						
	10	34	85	37	90	41	97	46	104	52	114	59	124	70	137	83	160	107	172	186	186	340	232	340	281				
	5	31	90	34	97	37	104	41	114	46	124	52	137	59	160	70	172	83	190	107	232	186	281	356	340	486			
27"	20	34	70	40	74	44	78	50	83	57	89	67	93	80	108	100	111	133	121	200	133	400	148						
	15	33	74	34	78	40	83	44	89	50	93	57	103	67	111	80	121	100	133	133	400	167	400	190					
	10	31	78	33	83	34	89	40	93	44	103	50	111	57	124	67	133	80	140	133	100	200	232	340	281				
	5	28	83	31	89	33	93	36	103	34	111	44	121	50	133	57	140	67	167	80	190	222	133	244	340	486			
26"	20	31	63	33	66	34	70	40	74	44	78	50	83	57	89	66	93	70	102	90	111	130	120	193	132	377	167		
	15	29	66	31	70	33	74	34	78	40	83	44	89	50	93	57	102	66	111	70	120	90	132	150	147	104	166		
	10	27	70	27	74	31	78	33	83	34	89	40	93	44	103	50	111	57	120	66	132	70	147	90	165	130	180		
	5	25	74	25	78	27	83	31	89	33	93	36	102	44	121	44	130	50	132	57	147	66	167	70	180	200	240		
25"	20	27	59	29	63	31	66	34	68	37	72	41	76	44	81	52	66	59	92	70	90	64	106	107	119	143	130		
	15	25	63	25	67	29	70	31	72	34	76	37	81	41	84	46	92	52	90	50	104	70	115	84	104	107	130		
	10	24	67	24	70	26	74	28	76	31	81	34	86	37	92	41	90	46	106	38	115	59	124	70	130	84	106		
	5	23	70	23	72	24	76	24	81	28	86	31	92	34	96	37	106	41	115	46	124	46	139	59	174	70	177		

sate pump would only require 56 hp, making a total of 156 hp.

The jet of a 5-deg. difference would require 20,000 gallons of water per minute against a 40-foot head if no booster pump were required, or approximately 400 hp. The air pump would require about 250 more, making a total of 650 hp.

The auxiliaries would have to be in pairs, with no possibility of having spares in reserve. There is no single dry vacuum pump manufactured large enough for this service.

The development of the steam turbine during the past few years has been so rapid and the vacuum requirements by the manufacturers so severe in order for them to make certain guarantees as to economies, that little thought has been given to the condenser requirements in order to obtain this specified vacuum. For this high duty, which is required in most cases, a definite hardship as to first cost and operating cost of the condenser has been placed upon the purchaser,

next step should be a study of the auxiliaries for the equipment. These can be divided into two kinds:

1—Motor-driven.

2—Steam turbine or engine-driven.

1. It is very easy to analyze the power requirements of the motor-driven air pump, circulating pump, hot-well pump, etc., power being taken from the switchboard and representing power not available for sale or other use.

2. The steam turbine or engine drive, however, brings up the question of the return of heat to the feed water, or heat balance, which often so complicates matters that we lose sight of the true power consumed. Roughly, 90 per cent of the steam heat of the auxiliaries will be returned as heat to the feed water, provided there is enough water of a suitable temperature to absorb this heat. The amount of feed water available for absorbing this heat varies with the load of the main unit. The result is that at times of light load there is a grave danger of showing an excess of

exhaust steam. This militates to some extent against the use of steam-driven auxiliaries, and has led to the development of combined drives using turbines and motors. Another feature to be taken into consideration is the growing use of economizers in connection with the boilers; the colder the water the more work being done by the economizers. This also emphasizes the desirability of avoiding an excessive amount of exhaust steam. It should also be pointed out that the above conditions have resulted in more attention to the economy of auxiliary turbines, which in turn has

practicable for over 40,000 pounds of steam per hour with a 28-inch vacuum. These are rarely used except for surface work.

3. The direct-acting, rotative, low-speed, dry vacuum pump, when used in connection with a proper condensate pump, is really the most efficient in point of power consumption, and where space is available is practicable up to, say, 250,000 pounds of steam per hour with a 28-inch vacuum, but for jet or barometric work at the same vacuum for only about one-half that amount of steam.

4. The hydraulic or turbo air pumps, such as the A. E. G., LeBlanc, or other suitable types, are very generally used and, although large consumers of power, they are very well adapted to all types of work where economy of space, convenience of arrangement, layout, etc., make them more practicable than other types.

5. The steam jet, which I mentioned above, has so

POUNDS OF CONDENSING WATER PER POUND OF EXHAUST STEAM (1000 B. t. u. per Pound)							
Vacuum	Difference between Discharge Water Temperature and Steam Temperature	Entering Water Temperature Degrees F.					
		40°	50°	60°	70°	80°	90°
29"	0	25.6	34.5	52.6	111.0	...	...
	5	29.4	41.7	71.5	250.	...	...
	10	34.5	52.6	111.0	...	...	...
	15	41.7	71.5	250.0	...	...	...
	20	52.6	111.0	...	...	...	...
28.5"	0	19.3	23.8	31.2	45.5	83.3	500.
	5	21.3	27.0	37.0	58.8	143.0	...
	10	23.8	31.2	45.5	83.3	500.0	...
	15	27.0	37.0	58.8	143.0	...	...
	20	31.2	45.5	83.3	500.0	...	...
28.0"	0	16.3	19.6	24.2	32.0	47.0	89.0
	5	17.8	21.6	27.6	38.2	61.6	160.0
	10	19.6	24.2	32.0	47.0	89.0	800.0
	15	21.6	27.6	38.2	61.5	160.0	...
	20	24.3	32.0	47.0	89.0	800.0	...
27.0"	0	13.4	15.4	18.2	22.2	28.6	40.0
	5	14.3	16.7	20.0	25.0	33.3	50.0
	10	15.4	18.2	22.2	28.6	40.0	66.7
	15	16.7	20.0	25.0	33.3	50.0	100.
	20	18.2	22.2	28.6	40.0	66.7	200.
26.0"	0	11.7	13.3	15.3	18.0	22.0	28.2
	5	12.4	14.2	16.5	19.8	24.7	32.8
	10	13.3	15.3	18.0	22.0	28.2	39.2
	15	14.2	16.5	19.8	24.7	32.8	48.8
	20	15.3	18.0	22.0	28.2	39.2	64.5

resulted in the use of high-speed turbines with reduction gears.

Air Pumps.

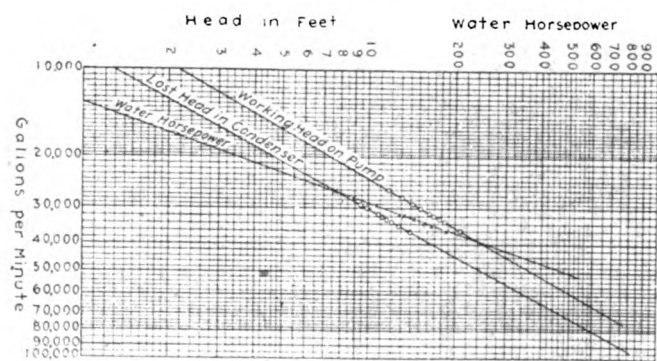
Air pumps are divided into several classes, as follows:

1. The old type direct-acting wet pump, being usually a standard steam-driven pump, sometimes of the suction valveless type. This cannot go above a 26-inch vacuum.

2. The rotative or flywheel direct-acting wet pump, such as the Edwards, Mullen, etc. There are also some well-known types of rotary pumps. All these have their qualifications, but only for a vacuum of less than 28.5 inches under any conditions, and they are quite limited in size and capacity, not being prac-

far been confined principally to marine and ice machine work, the reason being the high steam consumption. For example, a steam jet using 1,600 pounds of steam per hour from tests, shows an air-handling capacity of about 13 cubic feet of free air per minute at 1.5 inches partial pressure. This, I find in the example given, means on the same basis very nearly 4 per cent of the main unit power. The hydraulic pump using the same amount of steam with turbine drive would handle about 32.5 cubic feet of free air per minute under the same conditions. A rotative, dry vacuum pump of the same capacity, 32.5 cubic feet per minute, would require about 900 pounds of steam per hour. Steam pressure approximately 100 pounds.

In specifying an air pump, due consideration should be given the requirements under winter conditions with cold water. If condensing equipment is designed for a 28-inch vacuum with 70-deg. water, the purchaser should reasonably expect a corresponding vacuum with colder water. With water at 35 deg. for surface work the theoretical vacuum, based on a 15-deg. difference, with a properly designed machine, should produce a 29.354-inch vacuum, and the same for barometric or jet condensers based on a 5-deg.



Curves of centrifugal pump test.

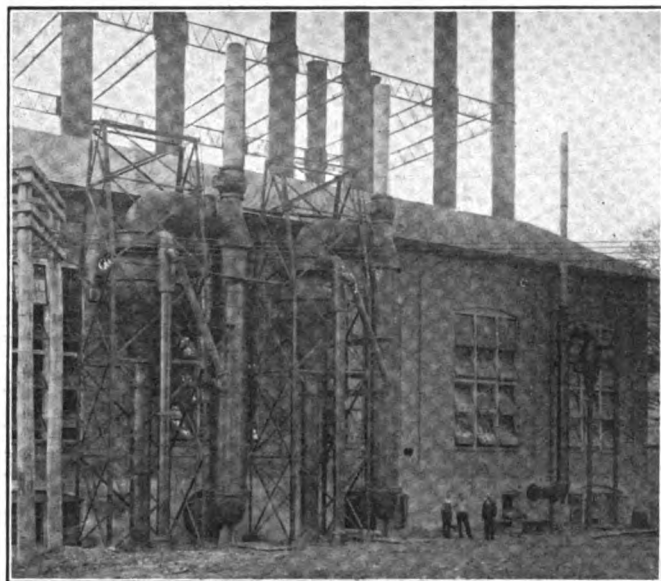
difference. No such guarantee can be made commercially by any manufacturer and can be made at all only by designing and furnishing a decidedly abnormal air-pump or air-handling equipment.

Condensate Pumps.

These are of the single or two-stage standard centrifugal, steam turbine or motor-driven or of the direct-acting duplex type, with some means of control, such as a float, to insure continuous supply of water to the pump.

Circulating Pumps.

Circulating or supply pumps are usually of the cen-



Two 4,000 kw. barometric ejector condensers.

trifugal type, turbine or motor-driven, or a combination of both.

Surface Condensers.

The requirements, as to surface, depend upon several things; the amount of water available, or the advisable amount to be pumped from an unlimited supply, the temperature, and the practicable rate of heat transfer per square foot of surface per mean degree of temperature difference. This rating as to surface depends principally upon the amount of heat that can be dissipated practically by each square foot of surface, this being determined by the heat transfer per degree difference between the mean temperature of the circulating water and the temperature of the vacuum to be attempted. For instance, with a vacuum of 28 inches, having a temperature of 101 deg. F. and with 70-deg. water at a 5-deg. difference; that is, a final temperature 5 deg. below the temperature of the vacuum, we have a 26-deg. rise or 13 deg. mean temperature rise, giving a mean water temperature of 83 deg. F., or 18 deg. mean temperature difference. Assuming 300 B. t. u. heat transfer per mean degree dif-

ference, each square foot of surface should then absorb 5,400 B. t. u.

At 10 deg. difference we have a 21-deg. rise, or 10.5 deg. mean rise, or a mean water temperature of 80.5 deg., or a mean temperature difference of 20.5 deg., which at 300 B. t. u. heat transfer would require each square foot of surface to absorb 6,150 B. t. u.

At 15 deg. difference we have 16 deg. rise, 8 deg. mean rise, 78 deg. mean water temperature, 23 deg. mean temperature difference at 300 B. t. u. heat transfer, or 6,900 B. t. u. per square foot.

At 20 deg. difference we have 11 deg. rise, 5.5 deg. mean rise, 75.5 deg. mean water temperature, 25.5 deg. mean temperature difference at 300 B. t. u. heat transfer, or 7,650 B. t. u. per square foot.

The water quantities for each pound of steam at 1,000 B. t. u. per pound would be in the above cases 38.5, 47.6, 62.5 and 90 pounds, respectively.

At high vacuum the specific volume of steam becomes enormous; 339.6 cubic feet for a 28-inch vacuum and 1,259 cubic feet for a 29.5-inch vacuum, and the addition of surface or baffles to a condenser of ordinary design may entirely defeat the purpose of the designer because of the increased resistance to the flow of steam between the tubes and through the condenser. Particular attention should, therefore be paid to providing steam lanes, or to the proper arrangement of tube banks, so as to keep down this resistance of flow to a minimum. In some well-known cases removal of 10 to 20 per cent of the tube surface has materially increased the vacuum.

Water and Surface Ratings.

The quantity of water available and the temperature usually determine the vacuum which it is practicable to maintain. This quantity can be varied for the same vacuum by varying the assumed terminal temperature difference, which will directly vary the surface for any given rate of heat transfer. A terminal temperature difference of 5, 10, 15 or 20 deg. can be used, and a ratio of heat transfer from 300 to 500 can be used. For standard commercial work a terminal temperature difference of 15 deg. is usually conceded to be the best practice, and a heat transfer of from 300 to 350 is conceded to be the most conservative.

This gives an idea of what may be accomplished in relation to water quantities, and of course if the surface be reduced in proportion to the rate of heat transfer (350, 400, 450 or 500 B. t. u. per mean degree difference) it would materially reduce the cost, but decrease the margin of safety for overloads and fouled tubes.

Regarding the surface per kw upon which we see so much discussion, no condenser is ever rated by kw, but by pounds of steam per hour, and in all cases the B. t. u. per pound of steam should be given. In a recent paper before the Boston Societies the following

statement was made as to surface for certain installations:

Station	Turb. capacity	Sq. ft. surf.	Sq. ft. per kw
Waterside No. 2.....	22,000	25,000	1.14
Waterside No. 2.....	30,000	50,000	1.66
Boston elevated	35,000	50,000	1.43
Gold street, Brooklyn.....	22,000	35,000	1.59
Fisk street, Chicago.....	25,000	40,000	1.60
Northwest Chicago	30,000	50,000	1.66
Seventy-fourth street, New York	30,000	50,000	1.66
Buffalo	20,000	33,000	1.65

I wish to bring to your attention some other recent installations, surface specified, with guarantees:

Turbine cap. kw	Sq. ft. surface	Surface per kw	Lb. st. per hour	Vacuum guar.	Temp. cir. water
10,000	19,000	1.90'	125,000	28"	75°
20,000	44,000	2.2'	240,000	28.5"	75°
10,000	20,000	2'	130,000	28.2"	70°
10,000	25,000	2.5'	135,000	28"	80°
20,000	40,000	2'	220,000	28.5"	70°
15,000	35,000	2.33'	200,000	27.25"	80°
20,000	35,000	1.55'	260,000	27.25"	85°
20,000	35,000	1.75'	268,000	27"	83°
25,000	45,000	1.8'	285,000	28"	75°
30,000	45,000	1.5'	385,000	28.4"	70°
15,000	26,000	1.73'	190,000	28"	70°
30,000	60,850	2.02'	345,000	28.5"	70°
15,000	26,300	1.75'	147,000	28.55"	70°

Water Velocities for Surface Condensers.

Regarding the much-discussed subject of water velocities for surface condensers, eminently good engineers have advocated as high as 10 feet per second, stating emphatically that 8 feet is conceded to be practical and standard.

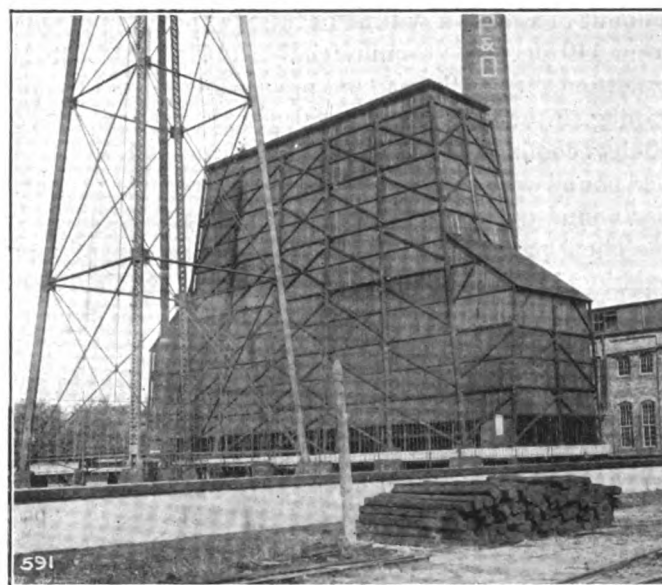
Since from tests of well-known large condensers a velocity of 4.7 feet per second seems to be the average, we will assume 5 feet. Now suppose that this velocity be increased to 8 or 10 feet, you can readily figure the excessive power requirements for such conditions. All talk of 8 to 10 feet per second seems to be absurd in view of the fact that there are very few commercial plants in practical operation under this condition.

By plotting the curve of head lost in the condenser against the discharge in gallons per minute on logarithmic paper, it is found that the head lost varies as the 1.75 power of the discharge; but since the velocity varies directly as the quantity of water we conclude that the head lost varies according to the 1.75 power of the velocity. This exponent is but slightly lower than the exponent 1.87 given in the American Civil Engineers' Pocket Book, or the exponent 2 generally conceded an average value. As the water hp depends upon the quantity times the head, the hp should vary as the cube of the velocity. It is found, by plotting the water hp curve, that the exponent is 2.9; that is, the hp varies as the 2.9 power of the gallons per minute, or of the velocity through the condenser tubes. Assuming a water velocity of 5 feet per second and 30,000 gallons per minute, by increasing this velocity to 10 feet per second the head loss in the condenser would be 35 feet, making a total head of 52 feet, instead of

10 and 15 feet; and a water hp of over 800, instead of 112.

Low Level Type Jet Condensers.

Water quantities are usually figured at a 5-deg. terminal difference as standard practice, although results have easily been obtained at the temperature of the vacuum or a 100 per cent water efficiency. The removal or tail pump, as already stated, requires the larger amount of power. With the usual river conditions the water has to be supplied to a cold well by a booster pump, drawn into the condenser by suction, and expelled against the vacuum plus any friction and outside static head. The booster pump power has not been considered in the example of power requirements



Natural draft chimney type cooling tower.

for the types already given. The air pump is required to remove air coming in with the water, as well as air entering through leaks in the exhaust or other piping, and air entering with the steam.

Barometric Condenser.

Here also the water quantities are figured as in the low-type jet machine. The water supply can be more easily obtained in that it can be pumped directly to the barometric head without booster or auxiliary pumps. The air pump requirements are the same as in the low-type jet. The efficiency of the booster pump for the low-type jet, when required, and of the supply pump for the barometric can be assumed as standard, consistent with good centrifugal pump design at a given head and quantity, but the removal pump efficiency for the jet is seldom over 50 to 60 per cent owing to the low velocity of the entering water in the impeller when pumping from a vacuum. The barometric type, therefore, as far as power requirements are concerned, is more efficient than the jet and less efficient than the

surface type. No condensate is reclaimed for boiler-feed purposes in either case.

Artificial Cooling of Water.

Where water supply is a serious problem some artificial method of cooling a given supply of circulating water is employed. This is done in several ways.

- Cooling Towers—1. Natural-draft, enclosed type. 2. Natural-draft, open or rack type. 3. Forced-draft. 4. Combined forced and natural-draft.

In standard cooling tower practice it has been determined that with the air temperature at 75 deg. F. and at 70 per cent relative humidity, the most economical vacuum to attempt is 27 inches, based on a 30-inch barometer, or a vacuum having a temperature of 115 deg. F. Rating all three types of condenser on a 5-deg. difference, thus requiring a minimum, uniform amount of water, it will be necessary to cool the water from 110 deg. F. Commercially, under the given air conditions, it has been found practicable to cool to only 85 deg. F. or sometimes to 80 deg. F., giving a 25 or 30-deg. cooling range, which with steam at 1,000 B.t.u. per pound would require 40 and 33.3 pounds of water per pound of steam, respectively.

The type of equipment to select would depend upon existing local conditions, such as space available and power consumption. The natural-draft open type requires more ground space and can be placed only where the vapors and driftage will do no harm to surrounding buildings or property, being seriously affected by wind conditions. This type requires a pumping head of approximately 30 feet and no other power. The natural-draft enclosed chimney type takes less ground space. The chimney or stack is usually about 75 feet high, this causing a positive draft at all times. It requires a pumping head of about 25 feet and no other power, and will be practically independent of wind conditions. The forced-draft type requires less floor space than any other type, but requires a pumping head of about 30 to 35 feet, and an additional amount of power for driving the fans, giving a draft independent of atmospheric conditions. The combination forced-draft and natural-draft tower requires less floor space than the chimney type natural-draft machine and more than the forced-draft machine, and requires about the same pumping head as the natural-draft chimney machine, plus the power to drive the fans when operating under forced-draft conditions. This type has the advantage of conservation of power under favorable atmospheric conditions, or of combining the forced and natural-draft under adverse conditions.

Spray Ponds; Spray Nozzles—It is impossible to state generally the area of a pond for a given quantity of water, but, generally speaking, at a working pressure of six to seven pounds on the spray nozzles, a pond of 3 square feet per gallon of water sprayed will be necessary. There are quite a number of details to

be considered, all having vital bearing on the subject of spray nozzle cooling. First, for spray nozzles the cooling effect can be increased by increasing the pressure at the nozzle. An increase of from 5 to 20 pounds would show an increase of from 1 to 12 per cent in cooling. The size of the nozzle should also be considered. Assuming a given size nozzle as rated at 100 per cent, an increase of up to 135 per cent can be obtained by decreasing the size, while by increasing the size a decrease of 60 per cent will be shown in the rated efficiency or cooling effect. The size of the pond or its storage capacity is a very valuable asset, in that the greater the storage volume the more time it requires in continuous service to pass it through the condenser. This time causes and equals what is called the lag in the pond temperature. The greater the lag the lower will be the average temperature in the pond. Therefore, the mean atmospheric conditions over the lag period can be assumed. Sprays are usually arranged in groups, so that free access by the air can be obtained at all times. The groups are arranged in single or double deck, depending upon the space conditions.

Natural Cooling Ponds—The area of a natural cooling pond is obviously very large, as the heat dissipated per square foot depends upon the relative humidity, the temperature of the water and the velocity of the air currents. These are naturally, on account of varied conditions, very discordant.

Quoting from G. F. Gebhardt's "Steam Power Plant Engineering:"*

"It appears from tests that under ordinary conditions, in the northern part of the United States, with engines using 15 pounds of water per hp-hour and a vacuum of 26 inches, a reservoir having a surface of 120 square feet per hp would be ample for cooling the condensing water."

This would mean about 60 square feet for each gallon of condensing water for a 26-inch vacuum, which, of course, would be greatly increased for a higher vacuum. The advantages, therefore, are, of course, with spraying under pressure.

In any water-cooling device 90 per cent of the cooling effect is through evaporation, and it is therefore of vital importance that sufficient unsaturated air be given free access to the proper quantity of water. The air in all cases should go off the tower or pond in a saturated condition.

I want to call attention here to the government records. These are usually taken at 8 a. m. and 8 p. m. and not as they prevail during the day, and under ordinary conditions existing in this country the relative humidity falls as the temperature rises during the day, or increases slightly as the temperature falls.

* Ed. 4, 1913, p. 517, quoting W. R. Ruggles, Proc. A. S. M. E., April, 1912, p. 607.

Problems of Hot Blast Stove Design

Calculations, Curves and Tables Presented Showing Methods of Computing Problems Involving the Combustion of Blast Furnace Gas.

By A. D. WILLIAMS.

In order to consider the design features of the hot blast stove it is necessary to approximate the flame temperature which may be expected from different proportions of the air supply and the effects of pre-heating either the air or the gas, or both. A set of curves covering a part of this ground was given on page 79 of the February issue. Fig. 1 shows a portion of this curve plotted to a larger scale and with additional data.

Practically all of the useful data covering heat

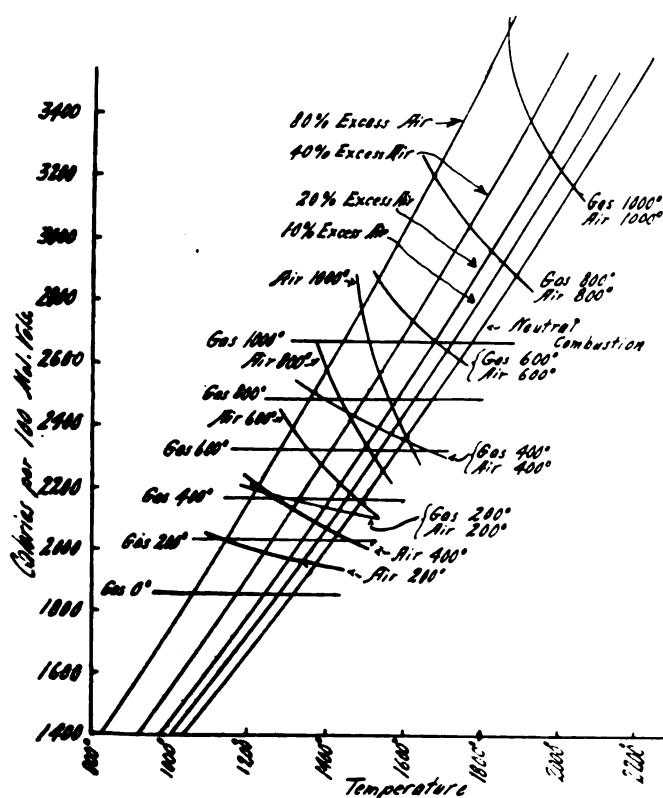


Fig. 1—Flame temperature curve.

transmission and the approximation of flame temperatures is given in metric units and owing to the fact that, in this system, the units of volume and weight are derived from the unit of length, the necessary computations may be made with one-third the labor required to attain the same result with English units. From the work of Bertholet and Vieille we have arrived at a knowledge of the heat released by the combustion or oxidation of various substances, while Mallard and Le Chatelier determined the heat capacity of

All temperatures Centigrade deg.

certain gases in the course of their investigations of explosives for the Commission du Grisou, appointed by the French government.

The heat of combustion at constant pressure of any body, simple or having a definite chemical composition, is the number of calories released by the combination with oxygen of the number of grammes of this body equal to its molecular weight, both the combustible and the oxygen having an initial temperature of 15 deg.

When the body is a gas or may assume the gaseous state, the molecular weight in grammes is equal to the weight of the substance which in the gaseous state occupies the same volume as that of two grammes of hydrogen at 0 deg. and 760 mm, that is, 22.32 liters or 0 m³ 02232.

All chemical formulas are based upon the combination of molecules and when volumes are used instead of weights the numerical work involved is very much simpler. The use of the molecular volume also permits a convenient translation from volumes to absolute weights by means of the molecular weights of the substances.

TABLE I.
Heat Released by the Oxidation of the Principle Combustibles.

Water assumed to remain as a vapor.

Substance burnt, one molecular volume	Molecular formula	Weight per molecule, grammes	Reaction of combustion	Calories released at constant pressure
Hydrogen	H ₂	2	H ₂ + 0.5 O ₂ = H ₂ O	58.2
Carbon	C	12	C + 0.5 O ₂ = CO	29.4
Carbon	C	12	C + O ₂ = CO ₂	97.6
Carbon Monoxide	CO	28	CO + 0.5 O ₂ = CO ₂	68.2
Methane (Formene)	CH ₄	16	CH ₄ + 2 O ₂ = CO ₂ + 2H ₂ O	195.2
Acetylene	C ₂ H ₂	26	C ₂ H ₂ + 2.5 O ₂ = 2CO ₂ + H ₂ O	304.9
Ethylene	C ₂ H ₄	28	C ₂ H ₄ + 3 O ₂ = 2CO ₂ + 2H ₂ O	319.6
Ethane	C ₂ H ₆	30	C ₂ H ₆ + 3.5 O ₂ = 2CO ₂ + 3H ₂ O	330.9
Sulphur	S	32	S + O ₂ = SO ₂	69.3
Sulphur	S	32	S + 1.5 O ₂ = SO ₃	91.8

TABLE II.

Substance burnt, one molecular volume	Molecular formula	Molecular weight, grammes	O ₂ required, vol.	Required vol. for To	Required vol. for N ₂	Required vol. for Air	Products of combustion volumes	CO	CO ₂	H ₂ O	N	Total
Hydrogen	H ₂	2	0.5	0.5	1.91	2.41	...	...	...	1.0	1.91	2.91
Carbon to CO	C	12	...	0.5	1.91	2.41	...	...	...	...	1.91	2.91
Carbon to CO ₂	C	12	...	1.0	3.81	4.81	...	...	1.0	...	3.81	4.81
Carbon Monoxide	CO	28	...	0.5	1.91	2.41	...	1.0	...	...	1.91	2.91
Methane	CH ₄	16	1.0	1.0	2.0	7.62	9.62	...	1.0	2.0	7.62	10.62
Acetylene	C ₂ H ₂	26	0.5	2.0	2.5	9.53	12.03	...	2.0	1.0	9.53	12.53
Ethylene	C ₂ H ₄	28	1.0	2.0	3.0	11.43	14.43	...	2.0	2.0	11.43	15.43
Ethane	C ₂ H ₆	30	1.5	2.0	3.5	13.34	16.84	...	2.0	3.0	13.34	18.34
Formene	C ₃ H ₆	42	1.5	6.0	7.5	28.59	36.09	...	6.0	3.0	28.59	37.59
Sulphur	S	32	...	...	1.0	3.81	4.81	1.0	...	...	3.81	4.81
Sulphur	S	32	...	...	1.50	5.72	7.22	1.0	...	...	5.72	6.72

Volumes can be valued in cubic feet or meters.

Combustion Volumes: Molecular, Neutral Combustion.

The heats of combustion given in this table are those at a constant pressure and assuming, in the case of the hydrogen, that the water is not condensed. These are the conditions under which combustion occurs in practice, where the furnace pressure is very close to atmospheric pressure and the water vapor is carried away in the off gases without condensation in the furnace.

In practice, however, the oxygen for combustion is supplied by the air and is, therefore, diluted by the accompanying nitrogen and a small amount of water vapor.

Dry air:	Oxygen	20.8 volumes.
	Nitrogen	79.2 volumes.
Average air:	Oxygen	20.4 volumes.
	Water vapor	2.0 volumes.
	Nitrogen	77.6 volumes.

Table II shows the amount of oxygen required for a number of the usual combustibles and the volume of dry air and accompanying nitrogen and the products of combustion. The calculations, however, may be greatly simplified if it is assumed that the air comprises 20 volumes of oxygen and 80 volumes of nitrogen, or one molecule of oxygen for four of nitrogen, neglecting the water vapor. The effect of this approximation is that it causes a slight error in the computed temperature of combustion, but this error is negligible in practice.

The temperatures of combustion as computed assume that combustion occurs in an athermal chamber; that is, that the entire amount of heat released is absorbed by the gases of combustion. In practice a portion of this heat passes into the walls of the combustion chamber. These walls may be of gaseous or solid material and will result in a considerable lowering of the flame temperature, depending, of course, upon their initial temperature. It is well known that a hot enclosure will show a higher flame temperature than the same enclosure when comparatively cold. In dealing with solid combustibles a portion of the heat is expended in raising the temperature of the combustible and is lost in the hot ashes. All of these heat losses are peculiar to each particular heat-generating chamber and cannot be allowed for in any generally applicable method of computation. Approximately the flame temperature resulting from the combustion of coal will be about 50 to 70 per cent of the theoretical flame temperature and with gaseous combustibles from 50 to 90 per cent of the theoretical, depending upon the furnace, and the character of combustion.

Combustion may occur with a reducing flame, a neutral flame or an oxidizing flame. The blast furnace and many smelting furnaces, as well as the gas producer typify combustion with a reducing flame, the supply of oxygen being less than that required to satisfy the combustible elements. In the smelting furnaces this acts to cause the taking up of oxygen

TABLE III.
Heat Capacity of Gases per Mol. Vol. 22.326.

Temperature	N ₂ 28 H ₂ 2	O ₂ 16 CO 28	H ₂ O 18 grammes	CO ₂ 44 grammes	CH ₄ 16 grammes
0	0	0	0	0	0
200 deg.	1.39	1.73	1.85	2.19	
400 deg.	2.82	3.69	3.99	4.85	
600 deg.	4.31	5.87	6.44	8.02	
800 deg.	5.82	8.23	9.07	11.46	
1,000 deg.	7.43	10.98	12.42	15.77	
1,200 deg.	9.05	13.87	15.55	20.37	
1,400 deg.	10.73	17.00	19.18	25.44	
1,600 deg.	12.46	20.35	23.10	30.99	
1,800 deg.	14.21	23.86	27.21	35.86	
2,000 deg.	16.05	27.76	31.84	43.55	
2,200 deg.	17.91	31.82	36.65	50.54	
2,400 deg.	19.84	36.10	41.76	58.02	
2,600 deg.	21.81	40.62	47.16	66.04	
2,800 deg.	23.82	45.64	52.84	74.42	

Combustion: Heat Capacity of Gases.

from the charged metallic or other oxides. The neutral flame is obtained when the oxygen supply is sufficient to satisfy the requirements of the combustible elements. The nearest approximation to this in practice is the so-called "surface combustion" system. The oxidizing flame or one containing an excess supply of oxygen is the one used in the majority of industrial heat applications.

The heat capacity of a gas or a mixture of gases is the amount of heat required to raise the gas from an initial temperature to a final temperature. That is, it is the number of calories which will be absorbed or given out by the gas between two temperatures. The specific heat of a gas at any temperature may be easily deduced from its heat capacity, as it is a function of the heat capacity; but the heat capacity between two given temperatures cannot be derived from the average specific heat of the gas between 0 and 100 deg. Mallard and Le Chatelier have derived the formulas for the heat capacity of a molecular volume of various gases by measuring the pressure produced by their explosion. Table III gives values computed from their formulas for temperatures from 0 to 2,800 deg. at intervals of 200 deg.

The use of the foregoing data is well illustrated in the accompanying computation tables from which

TABLE IV.

	Volumetric composition	Calories released per mol. vol.	Calories released	Weight of gas per 100 mol. vols.
H ₂	3.92	58.2	229	7.84
CO	23.95	68.2	1,630	671.00
O ₂	0.39	....	....	6.24
CO ₂	12.96	....	....	568.00
H ₂ O	1.65	....	....	20.80
N ₂	57.13	....	....	1,605.00
	100.00		1,850	2,887.88
			1,850 ÷ 2.232 = 835 cal. m ³ .	
			2,888.88 ÷ 2.232 = 1 kg. 30 per m ³ .	
			1.30 ÷ 1.29 = 1.01 specific gravity.	
H ₂	3.92			
CO	23.95			
O ₂	0.39			
N ₂	57.13			
	85.39			

TABLE V.
Combustion.

		Neutral			10 per cent Ex.		20 per cent Ex.		40 per cent Ex.		80 per cent Ex.	
		O ₂	H ₂ O	CO ₂	N ₂	O ₂	N ₂	O ₂	N ₂	O ₂	N ₂	O ₂
H ₂	3.92	1.96	3.92	.....	7.84	2.16	8.64	2.35	9.40	2.76	11.04	3.52
CO	23.95	11.98	.....	23.95	47.92	13.15	52.00	14.35	57.40	16.75	67.00	21.50
O ₂	0.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
CO ₂	12.96	.....	.....	12.96	.....	.....	.....	.....	.....	.....	.....	.....
H ₂ O	1.65	.....	1.65	.....	.....	.....	.....	.....	.....	.....	.....	.....
N ₂	57.13	.....	.....	.....	57.13	.....	57.13	.....	57.13	.....	57.13	.....
		13.94	5.57	36.91	112.89	15.31	118.37	16.70	123.93	19.51	135.17	25.02
Deduct	0.39	.....	.....	.....	1.56	0.39	1.56	0.39	1.56	0.39	1.56	0.39
		13.55	.....	.....	111.33	14.92	116.81	16.31	122.37	19.12	133.61	24.63
Off Gas .....	.....	.....	5.57	36.91	111.33	.....	.....	.....	.....	.....	.....	.....
Excess O ₂ .....	.....	.....	0.0	.....	.....	1.37	.....	2.76	.....	5.57	.....	11.08
Vol. Off Gas .....	.....	.....	153.81	.....	.....	100.66	.....	167.61	.....	181.66	.....	210.21
Vol. Air .....	.....	.....	67.75	.....	.....	74.60	.....	81.55	.....	95.00	.....	123.15
Excess Air .....	.....	.....	0.0	.....	.....	6.85	.....	13.80	.....	27.85	.....	55.40

TABLE VI.

Volumetric Composition of Off Gases and Air Supply.

	H ₂ O	CO ₂	O ₂	N	Wt. per m ³ kg.	Air m ³
Neutral combustion	3.63	24.00	0.0	72.37	1.41	0.68
10 Per cent excess air..	3.46	22.99	0.86	72.69	1.39	0.75
20 Per cent excess air..	3.32	22.03	1.64	73.01	1.38	0.82
40 Per cent excess air..	3.06	20.06	3.06	73.82	1.37	0.96
80 Per cent excess air..	2.67	17.70	5.28	74.34	1.34	1.23

TABLE VII.

Heat Capacity Off Gas and Gas.

	Mol. Vols. 200°	400°	600°	800°	2,000°
H ₂ O	5.57	10	21	33	46
CO ₂	36.91	68	147	238	335
N ₂	111.33	155	316	480	647
	233	484	751	1,028	1,346
	1,200°	1,400°	1,600°	1,800°	2,000°
H ₂ O	77	95	114	133	155
CO ₂	575	709	851	1,005	1,180
N ₂	1,010	1,198	1,380	1,585	1,785
	1,662	2,002	2,345	2,723	3,120
	2,200°	2,400°	2,600°	2,800°	3,000°
H ₂ + CO + O ₂ + N ₂ ..	85.39	118	246	366	495
H ₂ O	1.65	3	6	10	13
CO ₂	12.96	24	52	83	117
	165	304	459	625	808

TABLE VIII.

	Air supply mol. vols.	1.39°	2.82°	4.31°	5.82°	7.43°
Neutral combustion....	67.75	95	190	292	394	504
10 Per cent excess air..	74.60	104	210	322	435	556
20 Per cent excess air..	81.55	112	230	352	475	606
40 Per cent excess air..	95.00	133	270	412	556	710
80 Per cent excess air..	123.15	171	347	529	715	914

TABLE IX.

Heat Capacity Off Gas and Excess Air.

Tem- perature	Neutral	10% Excess	20% Excess	40% Excess	80% Excess
200 deg.....	233	10	243	19	252
400 deg.....	484	19	503	39	523
600 deg.....	751	29	780	59	810
800 deg.....	1,028	40	1,068	73	1,101
1,000 deg.....	1,346	51	1,397	102	1,448
1,200 deg.....	1,662	62	1,724	124	1,786
1,400 deg.....	2,002	73	2,075	148	2,150
1,600 deg.....	2,345	85	2,430	171	2,516
1,800 deg.....	2,723	97	2,820	194	2,917
2,000 deg.....	3,120	110	3,230	220	3,340
2,200 deg.....	3,523	.....	.....	.....	.....
O ₂ + N .....	.....	6.85	.....	13.80	.....
		.....	.....	27.85	.....

TABLE X.

Heat Released by Combustion.

	Neutral	10% Ex.	20% Ex.	40% Ex.	80% Ex.
Gas cold—Air cold.....	1859	.....	.....	.....	.....
Gas cold—Air 200°.....	1954	1963	1971	1992	2030
Gas 200°—Air cold.....	2024	.....	.....	.....	.....
Gas 200°—Air 200°.....	2119	2128	2131	2152	2195
Gas cold—Air 400°.....	2049	2069	2089	2129	2206
Gas 400°—Air cold.....	2163	.....	.....	.....	.....
Gas 400°—Air 400°.....	2353	2373	2393	2433	2510
Gas cold—Air 600°.....	2151	2181	2211	2271	2388
Gas 600°—Air cold.....	2318	.....	.....	.....	.....
Gas 600°—Air 600°.....	2610	2640	2670	2730	2877
Gas cold—Air 800°.....	2253	2294	2334	2415	2574
Gas 800°—Air cold.....	2484	.....	.....	.....	.....
Gas 800°—Air 800°.....	2878	2919	2959	3040	3199
Gas cold—Air 1,000°.....	2363	2415	2464	2569	2773
Gas 1,000°—Air cold.....	2667	.....	.....	.....	.....
Gas 1,000°—Air 1,000°.....	3171	3223	3272	3277	3681

the curves given in Fig. 1 have been plotted. The same data was used in plotting the curves given in the issue of February.

Table IV shows the computations for the heat released by combustion and the weight of the gas.

Table V shows the combustion computations for the gas burnt with the theoretical air supply and with the various percentages of excess air. This table gives the composition of the off gases, the volume of off gases resulting from the combustion of 100 molecular volumes of gas, the excess of oxygen, the excess of air supplied and the volume of air supplied.

Table VI shows the volumetric composition of the off gases, the specific weight of the off gases and the air supply per unit volume of gas.

Table VII shows the computations of the heat capacity of the off gases for neutral combustion and the heat capacity of the unburnt gas. The values are obtained by multiplying the number of molecular volumes of the different gases by the unit heat capacities given in Table III.

Table VIII shows the computation of the heat capacity of the air supplies derived in the same manner as Table VII.

Table IX shows the computation of the heat capacity of the off gases resulting from combustion with various excess air supplies.

The curves in Fig. 1 marked:

Neutral combustion
10 Per cent excess air
20 Per cent excess air
40 Per cent excess air
80 Per cent excess air

were plotted from the values in Tables VII and IX.

Table IX shows the heat released by combustion with a number of different conditions of preheated air, preheated gas, cold air and cold gas. This table was derived by adding to the heat value of the gas in Table IV, the heat capacity of the gas at various temperatures from Table VII and the heat capacity of the air supply at various temperatures from Table VIII.

The points given in Table X were then located on the curves previously drawn in Fig. 1 and curves or straight lines drawn through these points. The intersection points give the theoretical flame temperatures for the different combustion conditions and enable an approximation of the heat released and the theoretical

flame temperature for other combustion conditions to be made by interpolation.

These curves show that a considerable gain in temperature may be obtained by preheating the air and the gas and from them the amount of additional gas to obtain this preheating may be approximated. In order to do this last, however, the lower portion of the curve is necessary.

This curve shows that with preheating this gas might possibly be used for the melting of steel or for heating furnaces as well as for heating the blast for the furnace.

These methods may be applied to other gases and to solid, pulverized or liquid fuels, and while purely theoretical they will throw a very interesting light upon furnace operation.

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Prevention of Blast Furnace Breakouts

Bureau of Mines Bulletin Deals With the Causes and the Development of the Methods of Prevention of Bosh, Hearth, Jacket and Tapping Hole Breakouts.

By F. H. WILCOX.

This bulletin, which is arranged in three parts, treats of the causes and prevention of blast furnace breakouts, explosions and slips. The first part discusses blast furnace breakouts, the hazards therefrom, causes, and features of furnace design and methods of operation that tend to prevent breakouts or lessen their number, and points out safety measures to be adopted. The second part takes up the theory and causes of gas explosions at blast furnace plants and reviews the better methods in use for handling gas. The third part analyzes the causes of hanging and scaffolding in blast furnaces, with the resulting slips that frequently cause injury to the plant and danger to the workmen, describes features of construction and furnace design and methods of operation employed to prevent hanging and slipping, and suggests precautions and safeguards. This article deals with the first part of the bulletin only. Abstracts of the second and third parts will appear in the following numbers.

Owing to improvements in the design and operation of blast furnace plants breakouts, explosions and slips are becoming more and more infrequent, so that only the old and widely experienced furnace men have wide amount of knowledge concerning these troubles. This, however, does not lessen their danger and importance, and it is the purpose of the bulletin to take up their causes and methods of prevention from a technical standpoint.

Breakouts are classified according to the material that breaks out and also in relation to the location of

the break: breakouts of the blast, gas and coke in the bosh, breakouts of slag or cinder at the tuyere breast, and breakouts of iron in the hearth.

Bosh Breakouts.

Bosh breakouts may be caused as follows: (1) By conditions inside the furnace, such as high pressure of blast, very heavy slips, or severe working on the hearth walls, all of which may lead to (2) breaking of the hearth bands, ejection of cooling plates, or parts of the brickwork between the bands and the plates, or (3) cracking and opening of bosh jackets. The second and third items may usually be traced back to deficient construction or questionable design.

The development of bosh design was gradual up until about 1900, when changed conditions in the industry began to make marked changes in construction all over the blast furnace. It was, in brief, a progressive evolution; changes in fuel and ore required more limy slag, a more limy slag required hotter combustion, and this in turn required a stronger and hotter blast, which resulted in larger production, and larger production required better construction. Weaknesses developed, accidents happened, deficiencies were corrected, and one improvement led to another until there are now two distinct types of bosh construction which, so far as may be conceived, are the last word in construction, design, strength and security, namely: the banded and the jacketed types which are illustrated in Figs. 1 and 2.

The banded type of bosh is largely used on furnaces running on lake ores. It consists of brickwork in

An abstract of Bureau of Mines Bulletin 130.

which are inserted five to eight horizontal superimposed rows of bronze cooling plates. Heavy butt-riveted steel bands are placed around the brickwork between the rows of cooling plates to give it strength to resist bursting forces. The cooling plates are usually inserted through cast iron boxes. The boxes are used to help hold the brickwork in place when plates are removed and to make possible the use of shorter plates. The bands rest on the plate boxes or bear on special supports provided to keep them from slipping down. The scouring action of the slag on the brickwork of this type of bosh is to gouge out deep recesses between the rows of cooler plates and render the path very rough to descending materials. It might be expected that sections of brickwork would be thrown out of place by severe blows caused by slips, but the areas that are not bound by the bands.

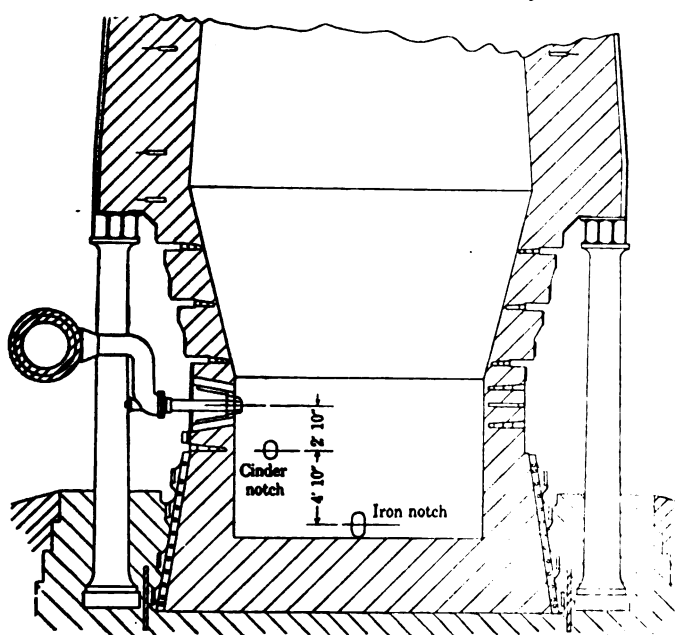


Fig. 1—Banded type of bosh construction.

cooler boxes, etc., are so small that such difficulties do not occur.

The cooling effect of the plates is discussed at length in the bulletin, and a comparison is made of the operation of furnaces operating with different numbers of plates, other conditions being as nearly the same as possible. The "safe" practice of over-cooling is common, especially in this country, and when carried to excess causes collections on the side of the bosh that impede the descent of the stock and cause slips. This also has a tendency to increase coke consumption.

The bulletin makes exhaustive treatment of such subjects as: Use of plate boxes, brickwork construction and strength, placing of plates, cooling water supply, and construction of bosh bands.

The jacketed bosh is designed to get away from the excessive cost of the plate and band construction, and to eliminate the rough wall caused by irregular erosion around the cooler plates. In this construction

the bosh is entirely inclosed by a riveted steel-plate jacket. The lining is usually made very thin, 9 to 13 inches, although a lining 24 inches thick is occasionally put in, and the exterior surface is cooled with a film of water, sprayed at the top, which in descending covers the plate work of the bosh and carries the heat away rapidly enough to cool the brick lining of the hearth below the slag-forming point. In this way the cutting action of the slag is prevented.

There are a number of systems for taking care of the cooling water and keeping the jacket covered with water. Annular and spiral troughs are used. Auxiliary sprays are common. The jacket is sometimes supplemented with cast iron staves with water pipes cast in. There is also a modification in the form of a jacket, built up of cast iron segments with water pipes cast in.

The author of the bulletin makes a comparison of the plate and band with the jacket type of construction with the following conclusion: In spite of the advantages of smoother slope, strength, cooling and tightness of the jacketed bosh, furnace men going from plants smelting lake ores to those using magnetites, hard ores, cinders and local ores usually construct the bosh at the first relining, according to their former experience—that is, with plate and band construction—while those who have tried the jacketed bosh on lake ores express themselves as perfectly satisfied with the plate and band bosh and have no desire to try the jacketed bosh again.

Tuyere Breast Breakouts.

The tuyere breast is comprised in that part of the hearth which extends from the bottom of the bosh to the top of the hearth jacket. The brickwork at this point is 18 inches to 2 feet 9 inches thick and is built of standard 9-inch brick inclosing the tuyere-cooler arches and cooling-plate openings. The tuyere breast in a modern 500-ton furnace is about 5 feet 6 inches high and the outside surface, with a 2-foot 6-inch wall inclosing a 17-foot hearth, 22 feet in outside diameter, is about 390 square feet, which is diminished by 12 cooler openings 30 inches in diameter and usually by 36 cooler-plate openings 5 x 24 inches in size, making a total exposed surface of approximately 330 square feet.

The tuyere breast is subjected to the most violent actions in the furnace. The temperature of combustion at the tuyeres may become as high as 3,300 deg. F., which is enough to soften the best brick so it will yield under compression. The slag which is formed in and above this region passes over the lining at the tuyere breast and has a severe cutting action on the brickwork under certain conditions. The pressure of the blast within the walls has a tendency to burst the brickwork open and, in the case of a bad hang, this effect becomes very great.

The chief factor in corrosion of the tuyere-breast

lining, however, is held to be erosion by the cutting action and back thrust of the blast and the particles carried in it at the high temperature and pressure of the hearth.

The bronze cooling plates inserted, usually without boxes, in the spaces between the tuyere coolers give the greatest protection against the destructive effects just noted by keeping the brickwork cool and in a resistant condition. A row of plates is frequently found beneath the tuyere coolers. In others the water-cooled hearth jacket is built higher. The tuyere breast is reinforced against the bursting forces by cast steel or iron segments bound together by steel bands, or by a steel-plate jacket with holes cut for

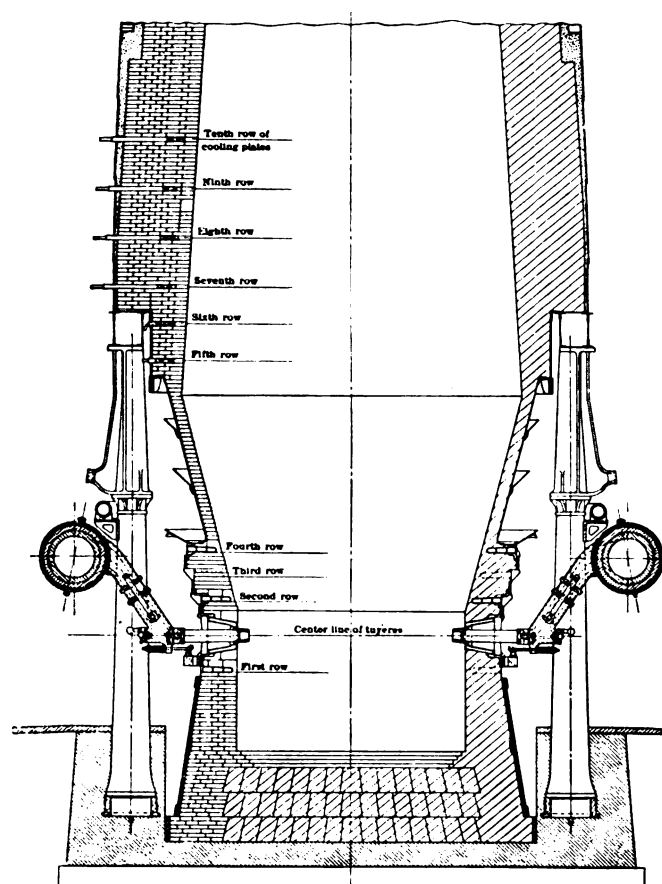


Fig. 2—Jacketed type of bosh construction.

cooler and plate openings. The latter form is most favored. A less common means of reinforcing is by two broad bands above and below the coolers, inclosing vertical buckstaves arranged between the tuyeres and the cooler plates. A packing space is provided which is tightly packed with clay, cement or asbestos.

The blowpipes and eyesights are great danger points of a slag breakout. There are times when the slag will reach the level of the tuyeres and will not flow from the cinder notch. A slip will sometimes throw slag and molten iron into the blowpipes, bustle pipe and even over into the hot blast main and valves. Under these conditions the eyesights sometimes break and allow molten materials to pour forth, or a hole is

burned in one of the blowpipes. Many attempts have been made to devise means of preventing the slag coming into the blowpipes, but none of them can be called successful. Eyesights have received much attention and there are a number of types that are convenient and safe both from the standpoint of the observer looking in and from breakouts. The bulletin takes up all the subjects mentioned in full detail, and gives accounts of a number of tuyere-breast breakouts that exemplify the different kinds of troubles.

Hearth Breakouts.

During the past few years serious breakouts occur more frequently at the hearth than at the bosh and tuyere breast. In fact, this has always been so, but with small amounts of iron in the hearth the breakouts were not necessarily serious, especially as the blast pressure was not high. With increasing tonnage and fast driving, they assumed serious proportions, sometimes wrecking the furnace, occasionally costing lives, and almost always causing bad messes, delays and inconvenience.

The destructive agencies within the hearth walls are as follows: (1) Erosion of the hearth walls by the blast, especially over the tapping hole; (2) disintegration of the brickwork by the chemical action of liquid slag and iron; (3) mechanical action of fluid iron in penetrating the joints of the brickwork. The result of these attacks is indicated in Fig. 3.

It is evident that the bringing down and accumulation of molten iron and slag in a zone of intensive combustion, pressure, and heat require exceptional construction. Improvement in strength, insulation and cooling has developed this part of furnace design to a point where plants at which one or more breakouts always occurred during a blast, have reduced the danger of breakouts to an almost negligible factor.

One point should be kept in mind in regard to hearth breakouts, and that is—regardless of the thickness of hearth walls or the cooling intensity on the exterior, all furnaces become worn away on the inside in much the manner shown in Fig. 3, so that the wall becomes relatively thin and retains its form only by virtue of the cooling and reinforcement of a metal jacket. This condition is found in furnaces blown out even after a short run. The study of the cause of this condition and of means of holding the hearth walls after it has developed provide a basis for understanding the occurrence of breakouts.

The abrasion of the blast and the chemical action of the slag continue in the crucible until the brickwork becomes thin enough for the cooling effect of the hearth jacket to arrest the progress of destruction. Great danger lies in not having the joints between the bricks tightly fitted and bound in place.

When a crack is open to molten iron only vigorous cooling can chill the iron and stop the crack. If the crack opens suddenly a jet of molten metal reaches the

jacket and cuts through quickly and without warning. The combating of breakouts through hearth walls above the tapping hole has developed standard forms of construction. Excessive thickness of hearth walls is liable to increase rather than decrease danger. Although there is a difference of opinion as to what the thickness of the walls should be, it generally lies between $31\frac{1}{2}$ and 42 inches.

Opinions and experience differ widely in regard to the use of packing between the brickwork and the hearth jacket. Probably if the packing is put in very tightly and offers sufficient resistance so that the expansion of the brick will close every joint, and is not more than 2 inches thick, it offers the greatest security, both against breakouts and the possibility of cracking the jacket.

There are a number of types of jackets in use. The two most favored types are the rolled steel-plate jacket and the cast iron or steel jacket. The plate jacket is usually cylindrical with internal and external strap-butt riveted joints. Just within the jacket are placed a series of cast iron cooling plates, side by side, all around the hearth. A packing space is essential. The cast jacket is made up of water-cooled segments in the form of a truncated cone. It is securely held together by means of shrunk links and steel bands fastened with wedges. Variations of these two types of jackets are common in connection with methods of cooling and fastening. Cooling the jacket is the great problem. Outside cooling with sprays and a deep ditch was once general, but is now going out of use. The bulletin gives a thorough discussion of the methods in practice. The following topics are also carefully considered: Breakouts below the tapping hole; danger in using spray-cooled, steel-plate jackets; formation of salamanders; causes destroying hearth bottom and falls; rate of lowering of hearth bottoms, and danger from deep salamanders. In addition to this the author gives in detail a number of typical examples of hearth breakouts.

Prevention of Breakouts Through Hearth Wall or Jacket.

Thus far no material ever used in hearth bottoms has resisted the destructive agencies inside the hearth. Carbon bricks have been given a thorough tryout, both in this country and Europe with little success. Besides carbon brick, various other materials which would supposedly be more inert than firebrick to the chemical actions taking place, such as silica brick, magnesite brick, and bauxite or alumina brick, have been proposed for hearth brickwork. In a practical way these proposals have not met with any enthusiasm, as furnace men feel that hearth failure is almost entirely due to chemical causes. All efforts in this country have been in the direction of better quality and uniformity of shape of firebrick, rigid construction, efficiency in water cooling, and elimination of

danger elements in advance of impending or possible breakouts.

The bulletin gives a complete treatment of the subject of types of firebrick used in hearths and takes up such subjects as the use of concave bottoms, keyed bottoms, the conical jacket, and different shapes in the hearth; and methods of laying the bricks.

The repeated experience of finding a salamander that extends to a considerable depth and has worked out under the jacket, even with the most painstaking care in selecting and laying hearth brickwork, has led furnace managers to extend the hearth jacket

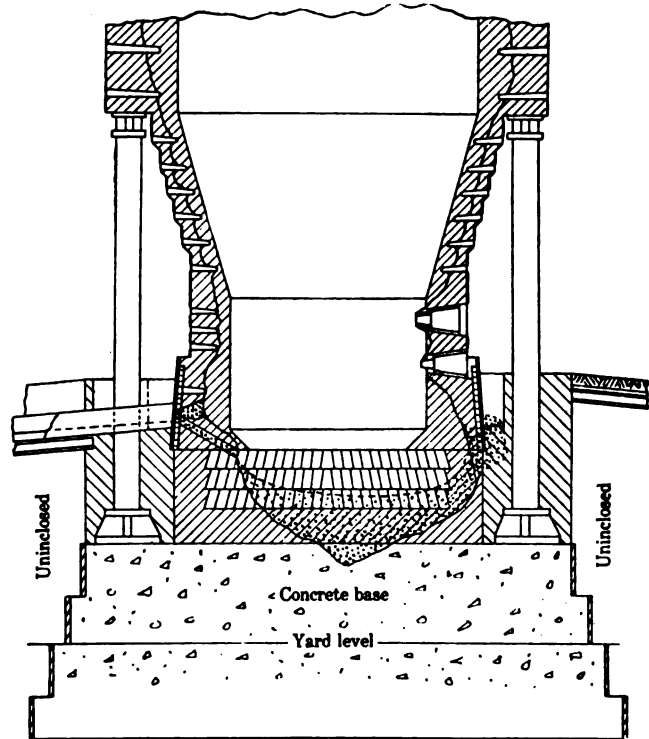


Fig. 3—Diagram showing how hearth walls are attacked.

downward. In present practice the hearth jacket extends, on an average, 4 feet below the hearth bottom, and most of the jackets recently built extend 4 feet 6 inches and 5 feet below the hearth bottom. The apparent need for deeper jackets to eliminate this difficulty with the salamander has led to the development of the subjacket, which has appeared in a number of forms.

The matter of leaving the salamander in on relining is the subject for difference of opinion. It forms a solid bottom which seldom remelts after being formed. On blowing in it may cause cold, high-sulphur iron, and trouble with the tapping hole. It expands upon heating in a way that cannot be foretold. At least part of it has to be removed on relining the crucible.

Under prevention topics the author lays great stress on the importance of design and construction. He also gives attention to protection of furnace columns, cooling the wall about the tapping hole, need of attention to the cooling water supply, care of the hearth ditch, precautions at blowing in, essential regularity

of casting and flushing, practice when casting is delayed, attention to signs of a breakout, procedure when a furnace is losing or holding its iron, and repairing the jacket and wall after a breakout.

Prevention of Tapping Hole Breakouts.

The preparation of the clay and handling of the mud gun are of great importance in insuring safety from accidents to the men in tapping and delays. The use of water with the clay, as done in some plants, is a source of danger. The plug should be made to fit the uneven places in the hole as closely as possible in order to be secure, and the mud should be packed well about the jacket at the outside of the hole. Careful cleaning of the hole at regular intervals is a safeguard against accidents. It is well for one shift to notify succeeding one concerning the condition of the hole and the length of the plug. The practice of blowing on the hole is pronounced poor practice by the author of the bulletin. Care should be exercised in working around the iron notch and opening the hole

pronounced, but the action of limy slags sufficiently fluid to work well is notably severe.

The preparation of the tapping hole for blowing in the furnace is attended with great care, because the first tapping is usually hard and the hole should be as near right in the beginning. The erosion of the tapping hole begins at the first cast. The angle is changed and the hole becomes deeper as production increases and the hearth is eroded away. The tapping hole becomes the hottest place in the hearth wall at times and various means are resorted to to cool the brickwork close to it. The use of cooling plate in the vicinity is dangerous, because the hot iron is liable to melt the plate, and the result is an explosion. The examples of accidents about tapping holes, given in the bulletin, are typical and bring the attention of the reader to the points of design and operation that are most pertinent to the subject.

The only danger of breakouts about the cinder cooler is escape of cinder between the large cooler and

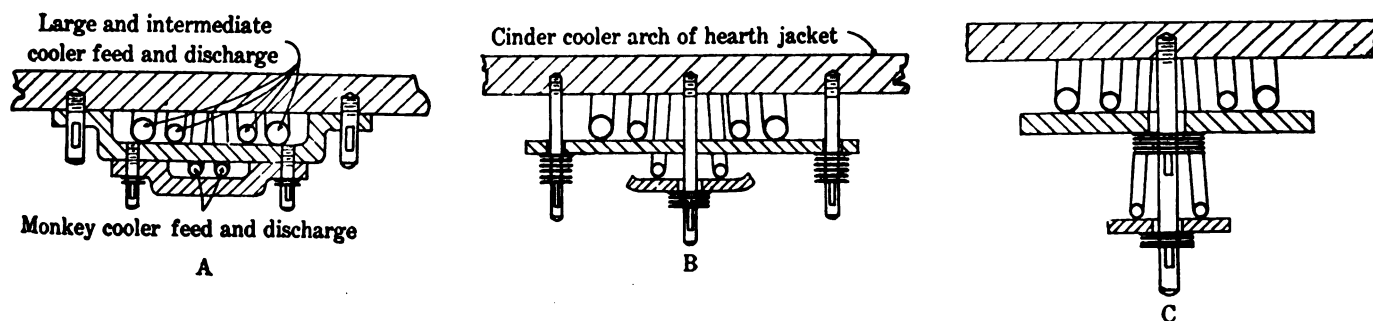


Fig. 4—Three types of cooler system.

when the cast has been delayed for any length of time. It is hazardous to stop the hole with the blast on. The gun should be left in the hole with the steam on for some time after the hole is stopped, in order to make the plug secure. The use of splasher plates or shields is encouraged as a protection for the workmen against the heat and possible accidents.

Tapping Hole Breakouts.

With hearth jackets and hearth brickwork strongly constructed and copiously cooled, the weakest point is immediately over and at the tapping hole. The iron notch is expected to withstand the erosion of fluid iron forced out at high velocity, the slagging action of cinder, which begins to come out with the iron during the latter half of the cast, and the cutting of the gas or blast sweeping down from the tuyeres when the iron sinks to a low level in the hearth near the end of the cast. To withstand this action there is provided simply a plug of fireclay, which fills the opening left in the hearth walls at lining, 6 x 24 x 36 inches in size.

Generally speaking, the limier and especially the richer in magnesia the slag is, the more severely is the clay in the tapping hole cut out and weakened. When the lime content becomes excessively high so that the slag is extremely mushy, the action is not

the brick walls, a rush of cinder when the intermediate cooler is changed, outbursts of slag and flame when the monkey is changed, or an explosion of the intermediate and the large cooler. If iron comes over the monkey by accident, it may cut the bronze and come in contact with the water inside, when all three coolers may be blown out of the furnace, and an outrush of furnace contents follow.

Breakouts about the cinder-notch cooler are minimized by painstaking care in setting and packing the cooler, which usually should be done after the kindling and scaffold have been placed in the hearth and bosh, and before the furnace is filled preparatory to blowing in.

The cooler system is held in the furnace by clamps of which three types are shown in Fig. 4. Of these three, type C is least desirable. The feed and discharge pipes, in addition to having cocks near the cooler arch, should, rather than rising directly up to the supply pipe and trough, lead around the furnace at least one-third, or better, one-half, of the circumference before being taken up, so that in event of cutting, burning, or a breakout at the cinder notch, the monkey boss can turn the water off, to avoid an explosion, without exposing himself to danger from escaping cinder, flame, or flying iron.

Development in Burning Coke Breeze

Discussion of Paper by Joseph G. Worker, Abstracted in Previous Issue, Showing Success of Burning Both Fine Anthracite Coal and Coke Breeze — Stoker Development Stage Has Passed.

By JOHN VAN BRUNT.*

In looking over your February, 1918, issue of THE BLAST FURNACE AND STEEL PLANT, I note an article by Joseph G. Worker on fuel economies in steel mill power plants, in which he states that no satisfactory method has been successfully developed to burn fine anthracite coal or coke breeze.

If Mr. Worker had thoroughly investigated this matter, he would have found that in the anthracite regions stokers are quite generally employed in the larger plants in burning the finest sizes of anthracite coal. Companies like the Susquehanna Coal Company, Philadelphia & Reading Coal & Iron Co., Delaware & Lackawanna and Lehigh Coal & Navigation companies have equipped, and are equipping many of their plants with the Coxe traveling grate, on which they are burning anthracite coals, all of which will pass through a 3/16-inch screen.

The smallest sizes of anthracite steam coals are No. 2 buckwheat, or rice and No. 3 buckwheat or barley. No. 4 buckwheat is not generally used outside of the anthracite regions. The screening sizes are as follows:

- No. 1 buckwheat through 9/16-inch over 5/16-inch.
- No. 2 buckwheat through 5/16-inch over 3/16-inch.
- No. 3 buckwheat through 3/16-inch over 3/32-inch.
- No. 4 buckwheat through 3/32-inch over 3/64-inch.

All that passes through a 3/64-inch screen is usually known as silt. Any one of the above sizes are very successfully burned and satisfactory ratings are obtained from the boilers.

In the vicinity of New York and Philadelphia there are a large number of plants equipped with the Coxe stoker, all of which are burning No. 3 buckwheat. The capacities obtained vary from 125 per cent to 175 per cent of rating continuously, frequently going up to 200 per cent, and over for short periods. The efficiency will range between 65 and 70 per cent at 150 per cent of rating. In the anthracite regions even higher capacities are obtained at some sacrifice in efficiency. When burning the finest sizes, that is, No. 4 buckwheat and silt, the rate of combustion is considerably lower than the larger sizes. To obtain satisfactory ratings, the grate surface is increased very materially, so that at rates of combustion of 22 to 26 pounds per square foot, 150 to 175 per cent of rating is obtained continuously.

During the past two years over 500 of these stokers have been installed under an aggregate of over 200,000 boiler horsepower in various plants in the East for burning anthracite coal. As a general thing these stokers have been installed for the purpose of burning No. 3 buckwheat and smaller sizes, because of the difference in

price between this size and No. 1 and No. 2 buckwheat. The stoker, however, will satisfactorily burn both No. 1 and No. 2 sizes with slightly better economy than the No. 3. The No. 1 buckwheat is the largest size that can be satisfactorily burned on this stoker.

In connection with the burning of coke breeze, the Coxe stoker has passed the development stage. Installations have been made, and are in operation in Alabama, in the Pittsburgh district, and also in the East, and in the vicinity of Chicago. Coke breeze from beehive, and by-product ovens and also from gas works has been successfully burned. The efficiency and capacity is approximately the same as with anthracite coal. There are now in operation, and in process of installation over 100 stokers under boilers aggregating 50,000 horsepower rated capacity. These stokers are developing, and are designed to develop from 150 to 200 per cent of rating continuously at efficiencies from 65 to 70 per cent. The coke breeze, as burned, will all pass through a half-inch screen, and will approximate 11,000 to 11,500 B. t. u.'s dry, 10 to 20 per cent moisture, 1 to 3 per cent volatile matter, 15 to 30 per cent ash.

The companies installing these stokers are of national reputation.

In addition to burning anthracite and coke breeze, the stoker will handle bituminous coals, and is well adapted to burn the lowest grades of semi-anthracite semi-bituminous or bituminous.

There can be no exception taken to the balance of Mr. Worker's article. The writer believes that a higher standard of intelligence in boiler room operation is essential, and that no amount of equipment either of the stokers, or indicating and recording apparatus will produce satisfactory economies, unless they are backed up by intelligence in the fire room force.

There are many instances where boiler plants have been equipped with modern stokers, coal scales, water meters, indicating and recording flow meters and CO₂ meters and recording pyrometers, and no use whatever made of the data obtained, due to the lack of intelligence, supervision, or a definite plan of procedure.

The services of a competent man are required to make proper use of equipment of this kind, one who can correctly interpret the meaning of the various records, and in too many cases this service is not supplied, the entire equipment being turned over to the care of the boiler room force, no one of whom understands what records mean, nor are they competent to keep the instruments in adjustment and repair.

* Chief engineer Combustion Engineering Corporation.

PRODUCTION TOPICS

ALUMINA INFLUENCE IN BLAST FURNACE SLAG.

By C. R. JONES, Chemist, Lebanon Blast Furnace Co.

Referring to an article in the March issue of THE BLAST FURNACE AND STEEL PLANT by A. L. Field and P. H. Royster, regarding the high alumina content of the slag causing the slag to show from 6 to 10 per cent less than its true alumina content when treated with the usual hydrochloric acid method, I wish to suggest that it is not due to the high alumina content of the slag that this difference in the solubility with the hydrochloric acid treatment occurs, but to the conditions in the furnace and the presence of magnesia in the burden. The same difficulty will be met with in a slag with a low alumina content.

I have found that the impurities in the insoluble matter after the hydrochloric acid treatment will vary from .10 to 10. per cent, but the variation does not travel with the alumina content. To illustrate, I give below four slag analyses for SiO₂ and Al₂O₃ for four successive days. The first day, the furnace was on one-half limestone and one-half dolomite, and the last three days all dolomite stone was used:

	1	2	3	4
Insoluble matter	28.56	31.28	30.40	37.76
Silica	27.42	26.60	25.50	23.70
Impurities	1.14	4.68	4.90	14.06
Alumina from soluble portion.....	19.22	15.80	14.29	9.58
Alumina from insoluble portion....	.32	3.10	3.36	9.00
Total alumina	19.54	18.90	17.65	18.58

You will note that in the first case, there is higher alumina in the slag but less remaining with the insoluble matter, and when we consider the three latter slags being with all dolomite stone, it would seem that the conditions in the furnace are the real cause of this difference, as with half and half stone sometimes the alumina held in the insoluble matter is a great deal higher than in this case of all dolomite stone, except the last one.

I think this shows clearly that the high alumina content in itself has nothing to do with the solubility of the slag in hydrochloric acid. At times, the treatment with hydrochloric acid with the alumina as high as illustrated or higher will yield the silica pure and all the alumina in the filtrate. Therefore, because the alumina is over 12 per cent, it is no proof that the sample requires special treatment, but that the difference in the stone burden and temperature of the furnace is the reason for the slag not being completely soluble in hydrochloric acid.

EXPERIMENTS IN FUEL COMBUSTION.

The Bureau of Mines, Department of the Interior, after several years of experiments in fuel combustion in a special furnace, makes the announcement that from the results it is possible to design a furnace with considerable more assurance as to its capabilities than has heretofore been possible.

Starting with the analysis of the coal to be used and the rate at which it is to be burned, the furnace dimensions in feet and inches can be designed with a reasonable assurance of obtaining a desired degree of completeness of combustion.

The bureau has just made a report on this subject, Bulletin 135, "Combustion of Coal and Design of Furnaces," by Henry Kreisinger, C. E. Augustine, and F. K. Ovitz. The publication marks a period in work approved in 1906 by a National advisory board appointed by the President to advise the government concerning fuels. The bureau proposed to conduct such

experiments as would make it possible to design fuel-burning furnaces on a rational basis rather than by the cut and try methods of the past. The process carried on in the combustion space is influenced by many factors, the most important of which are the volume and shape of the combustion space; the kind of coal used, especially the character and amount of volatile matter it contains; the rate of firing; the quantity of air supplied over the fuel bed; the rate of mixing the air with the combustible rising from the fuel bed; the rate of heating the coal; and the temperature in the combustion space.

The qualitative effects on the rate and completeness of combustion of many of these factors have been known for a long time; but the quantitative data, presented in definite units, of seconds, pounds, feet, or percentages, have been lacking. To obtain such definite information a study of combustion in the space beyond the fuel bed was undertaken, and the results of extensive tests are given in this bulletin. About 100 elaborate tests were conducted in a special furnace using three kinds of coal—Pocahontas, Pittsburgh, and Illinois—and at rates of combustion covering the full range found in practice. These are believed to be the most extensive tests of the kind ever undertaken.

While the bulletin is especially for those interested in the design or reconstruction of fuel-burning furnaces, it contains much of interest to the general engineer interested in fuel problems. Some of the statements sure to arrest the attention of the interested engineer are as follows:

The size of the combustion space required appears to be directly proportional to the percentage of oxygen in the moisture-free and ash-free coal.

The percentage of excess air that gives the best results varies with the size of the furnace and the kind of fuel. This fact explains why in one plant the highest efficiency may be obtained with 14 per cent of CO₂ in the gases, and in another plant with only 10 per cent of CO₂.

Soot is formed at the surface of the fuel bed by heating the hydrocarbons in absence of air. It is not formed by the hydrocarbon gases striking the cooling surfaces of the boiler. As a matter of fact only a very small trace of the hydrocarbon gases ever reach the surface of the boiler. Hydrocarbons that do so are prevented from decomposition by the cooling effect of the contact. The cooling surfaces do not cause the formation of soot; they merely collect soot and prevent its combustion.

It seems that most mechanical stokers are smokeless not because they burn the smoke, but because they burn the coal in such a way that very little soot or smoke is produced. Hand-fired furnaces are smoky because soot is produced in or near the fuel bed.

MAKING SUBSTITUTIONS FOR NATURAL GAS.

(Continued from page 158)

This calculation shows that, notwithstanding the high first cost for a powdered coal plant, the operating cost of such a plant is far below that of a fuel oil plant, which is only due to the high cost of the oil. The operating cost for a gas producer plant is again less than that for a powdered coal plant, with the further advantage that the first cost of the former is only about one-third of the latter.

The cost for changing furnaces has not been considered in the preceding calculations, since this is a figure which depends entirely on the kind of furnaces and on the condition they are in. Besides, no repair charges have been introduced for a similar reason. The final result, however, will not be altered to a marked extent by these two omissions.

NEWS OF THE PLANTS

PIG IRON PRODUCTION IN THE UNITED STATES IN 1917.

The American Iron and Steel Institute has recently issued statistical bulletin No. 1 for 1918, showing the production of pig iron in the United States during 1917.

All pig iron and ferro-alloys are included, whether made in blast furnaces or in electric furnaces. Pig iron made with bituminous coal is included under coke pig iron. Pig iron made with mixed anthracite and coke is included in anthracite pig iron. Pig iron made with electricity is included in coke pig iron. Low-phosphorus pig iron, that is, iron running under 0.04 in phosphorus, is included in Bessemer pig iron. Pig iron containing from 0.04 to 0.10 per cent of phosphorus is classified as Bessemer. The figures for 1913 and subsequent years include under basic iron a small quantity of charcoal iron of basic grade. In 1912 and prior years charcoal pig iron of basic quality was not included in the basic production. Nearly all the charcoal iron is classed as foundry pig iron. Ferro-silicon is included in foundry pig iron. Pig iron containing 7 per cent or over of silicon is classified as ferro-silicon. Under "all other goods" are included white and mottled iron, direct castings, and miscellaneous ferro-alloys. Where not separately stated ferro-manganese and spiegel-eisen are included in "all other."

The following tables taken from the bulletin show the half-yearly production of all kinds of pig iron, and the productions by grades through 1900-17. It will be noted that with the exception of basic, malleable, and "all others," the production was less in 1917 than in 1916; the total gross tonnage fell off 787,900 tons.

Half-Yearly Production of All Kinds of Pig Iron.

States	Blast Furnaces				Production—Gross Tons. (Includes spiegeleisen, ferro- manganese, ferro-silicon, ferro-phosphorus, etc.)		
	In blast June 30 1917	In	Dec. 31, 1917 Out	Total	First half of 1917	Second half of 1917	Total 1917
Massachusetts ..	1	1	1	2	4,305	6,222	10,527
Connecticut	2	2	1	3			
New York	21	21	4	25	1,118,482	1,299,045	2,417,527
New Jersey	4	5	0	5			
Pennsylvania	136	122	41	163	7,790,514	7,749,214	15,539,728
Maryland	4	2	3	5	234,589	187,623	422,212
Virginia	12	15	4	19	231,937	288,374	520,311
Alabama	34	34	13	47	1,494,479	1,459,226	2,953,705
Georgia	0	1	3	4	282,548	279,403	561,951
Texas	0	0	2	2			
West Virginia	4	3	1	4	201,296	168,655	369,951
Kentucky	4	4	3	7			
Mississippi	0	0	1	1	4,269,708	4,248,695	8,518,603
Tennessee	12	10	6	16			
Ohio	72	64	15	79	1,810,137	1,672,959	3,483,096
Illinois	22	18	7	25	1,200,122	1,457,381	2,657,503
Indiana	12	13	1	14			
Michigan	12	12	2	14	392,864	345,677	738,541
Wisconsin	6	5	3	8			
Minnesota	3	3	0	3	227,254	226,488	453,742
Missouri	2	2	0	2			
Iowa	0	0	0	0	0	0	0
Colorado	4	3	3	6			
Oregon	0	0	1	1	0	0	0
Washington	0	0	1	1			
California	0	0	1	1	0	0	0
Total	367	340	117	457	19,258,235	19,389,162	38,647,397

Production of Pig Iron by Grades, 1900-17.

Years	Basic	Besse- mer	Found- ry	Malle- able	Forge	All other	Total Gr. tons
1900...	1,072,376	7,979,327	3,376,445	173,413	793,092	394,589	13,789,242
1901...	1,448,850	9,596,793	3,548,718	256,532	639,454	388,007	15,878,354
1902...	2,038,590	10,393,108	3,851,276	311,458	833,093	393,722	17,821,307
1903...	2,040,726	9,989,908	4,409,023	473,781	783,016	312,798	18,009,252
1904...	2,483,104	9,068,659	3,827,229	263,529	550,836	273,676	16,497,033
1905...	4,105,179	12,407,116	4,758,038	635,236	727,817	358,994	22,992,380
1906...	5,018,674	13,840,518	4,773,011	699,701	597,420	377,867	25,307,191
1907...	5,375,219	13,231,620	5,151,200	920,290	683,167	419,850	25,781,361
1908...	4,010,144	7,216,976	3,637,622	414,957	457,164	199,155	15,936,018
1909...	8,250,225	10,557,370	5,322,415	658,048	725,624	281,789	25,795,471
1910...	9,084,008	11,245,642	5,290,447	843,123	564,157	305,590	27,303,567
1911...	8,520,020	9,409,303	4,468,940	612,523	408,841	229,910	23,649,547
1912...	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913...	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914...	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244
1915...	13,063,214	10,523,306	4,843,899	829,921	316,214	309,659	29,916,213
1916...	17,684,087	14,422,457	5,553,644	921,486	348,344	504,779	39,434,797
1917...	17,671,662	13,714,732	5,328,258	1,015,579	345,707	571,459	38,647,397

PROJECTED STEEL WORKS FOR NORWAY.

The village of Risør, Norway, which is between Christian-sand and Christiana, is projecting steel works and rolling mills to turn out 30,000 to 40,000 tons per year. It will utilize as far as possible electric power and electric heat for smelting. This will be derived from the Hoge Falls, the first transmission project being 22,000 hp. It is said that from 150,000 to 200,000 hp may be obtained from these falls.

NEW COMPANIES FORMED.

Four subsidiary organizations of the Tennessee Coal, Iron & Railroad Company, namely, the Fairfield Steel Company, the Chickasaw Shipbuilding Company, the Chickasaw Land Company and the Chickasaw Utilities Company, have filed incorporation papers in Birmingham. The purpose of these companies is to develop a shipbuilding and accessories plant at Fairfield and Mobile. The developments at Fairfield and Mobile are being rushed. At Fairfield, where additional steel plants will be erected for the production of steel plates and shapes for shipbuilding, the actual erection of buildings is started, the American Bridge Company having the bulk of these contracts. Machinery has been ordered, and within the next 60 to 90 days will begin arriving.

The Hudson Sheet & Tinplate Co. expect to have their new plant in operation about June 1. The plant will consist of four hot mills, two stands of cold rolls, turning machines and a pickling machine.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace & Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly, at Pittsburgh, Pa. [Report for April 1, 1918.]
 Publisher—National Iron and Steel Publishing Company, 108 Smithfield street, Pittsburgh, Pa.
 Editor—A. M. Staehle, 108 Smithfield street, Pittsburgh, Pa.
 Managing Editor—Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.
 Business Manager—Adam W. Tritsch, 108 Smithfield street, Pittsburgh, Pa.
 (Names and addresses of stockholders holding 1 per cent or more of total amount of stock):
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 Adam W. Tritsch, 108 Smithfield street, Pittsburgh, Pa.
 R. E. Denmore, 612 Union Trust Building, Detroit, Mich.
 Mary A. Howe Estate, Pittsburgh, Pa.
 Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.
 Sworn to and subscribed before me this 21st day of March, 1918.
 JOHN N. ENGLISH, Notary Public.
 (My commission expires March 9, 1919.)

Some Pointers on By-Product Coke Oven Operations

THE BY-PRODUCT COKE OVEN AND ITS PRODUCTS

By WILLIAM HUTTON BLAUVELT.*

The technical and engineering problems in the manufacture of coke are to-day the problems of the by-product oven. Except in a few special localities, practically no beehive ovens have been built in the United States for the last 5 or 6 years except as renewals of old plants, and during these years the total number of beehive ovens in existence has been steadily falling. On the other hand, the number of by-product ovens has increased from 4,624 in 1911 to a total of about 7,660 in operation at the end of 1917; with 2,800 building this makes a total of about 10,460 which will be in operation in 1918, or shortly thereafter.

Preliminary government estimates place the total production of coke for 1917 at 56,600,000 tons, the largest tonnage in the history of the industry. Of this 34,000,000 tons or 60 per cent was beehive, and 22,600,000 tons, or 40 per cent was by-product coke. Some time in 1918 the production of by-product coke should pass the beehive output, and when the by-product ovens now building are completed the total by-product capacity will be about 40,000,000 tons of coke per annum, which is over 70 per cent of the record-breaking total coke production of 1918. The reason for these changes in the coking industry are familiar to all of us, and need not be discussed here.

Improvement in Oven Design.

Since the by-product oven was brought to this country from Europe, in 1892, it has been radically improved, and from the point of view of American metallurgical practice it is safe to say that the American ovens are superior to those of Europe. The points of superiority are mainly those of larger units and larger output per unit, and the greater extent to which labor saving machinery has been introduced. The increased output is largely due to the use of silica refractory material, which permits higher heats and shorter coking time than are employed in Europe. The modern American oven will carbonize commercially more than 20 tons of coal per day, and contrary to the European idea that slower operation is necessary to conserve the plant, this rate of operation with only current repairs, can be maintained for an indefinite time. The by-product oven is not old enough in the United States to make it possible to state from experience how long an oven can be operated at maximum efficiency. There are a number of plants in different parts of the country which were built 16 or 18 years ago, which are more efficient to-day than in the first year of operation, and which show costs of operation which compete well with those of the most modern plants.

The early ovens were economical in heat consumption because the heat in the waste gases was utilized efficiently in raising steam for the operation of the plant. On account of the growing demand for oven gas for metallurgical and other uses, the change to the regenerative type of oven has been general. While this type of oven is not so economical of the total heat produced by the combustion of the gas as is the combined oven and boiler plant, it makes available for use half again as much of the surplus gas as did the older type of oven. Modern ovens require for carbonization of the coal less than 40 per cent of the total heat in the gas produced.

Description of Oven.

A description of one of the modern types of oven may be appropriate here. The by-product oven is essentially a closed chamber, heated from the outside, and the volatile matter of the

coal is distilled air being carefully excluded. This point distinguishes it in principle from a beehive oven, where the heat is generated by combustion within the oven itself, with the resulting destruction of everything except the coke. The oven consists of a chamber about 36 feet (11 m.) long, 12 feet (3.66 m.) high, and a width depending upon the coal that is to be carbonized. In American practice the average width varies from 16.5 to 21 inches (41.9 to 53.3 cm.). Modern ovens usually have about 2 inches (5 cm.) of taper toward the discharge end to facilitate the pushing of the coke.

The ovens are usually heated by a portion of the gas recovered from the distillation of the coal, although sometimes producer gas is substituted. In all the successful ovens this gas is burned in a series of flues which control the travel of the burning gases and distribute the heat over the entire side of the oven. The success of any oven design depends very largely upon the ability to correctly distribute the heat over the entire surface which forms the wall of the oven, and it is by no means an easy problem to control this distribution accurately over an area of 432 square feet (40 sq. m.). In some ovens the flues composing the heating system are vertical and in others horizontal.

Different systems have their advocates, and details have been worked out so that they can be relied upon to give the uniformity of heating necessary for satisfactory operation. Naturally the representatives of each system prefer their own type. The advocates of the horizontal flues find them more accessible for supervision, easier to control, and easier to maintain. The somewhat lower temperature that can be maintained in the upper flues under all conditions of operation is a desirable feature for the best results. A feature of one oven is the strong middle wall between the ovens extending from the foundation to the top, which gives the structure great stability and permanence and acts as a heat reservoir to help maintain uniform temperatures, which is important, because when a new charge of cold wet coal is dropped in the oven there is a great demand for heat to start the coking process quickly. These middle walls also permit any oven to be repaired or entirely relined with a minimum interference with adjacent ovens.

Heating the Oven.

Another description shows the flow of the air and gases through the system. In this system one pair of dampers near the stack does all the reversing of the air and gas. The cold air enters from a fan located at a point near these dampers, flows through one of the two main flues, and is distributed to the regenerators by a system of firebrick slides. The air is heated in the regenerators to about 1,000 to 1,100 degrees C. before entering the flue system of the oven and meeting the gas to be consumed.

This gas is supplied at several points in the flue system, and it flows steadily through the supply pipes, its direction in the oven being reversed by the reversal of the current of air, so that no attention need be given to this point by the operator. That is, when the currents are flowing upward through the flue system each gas stream is bent upward and burns in the flue above the gas pipe, which is opposite the partition wall.

When the flow is downward, the gas streams are bent downward. By means of these several supplies of gas the heat is supplemented as needed and all the air supplied is consumed by the last admission of gas. The products of combustion pass out to the other regenerator and thence to the reversing dampers and chimney in the same manner as in an open hearth furnace.

* Paper read before A. I. M. E. meeting, New York, February, 1918.

INDUSTRIAL SAFETY

THE PROGRESS AND POSSIBILITIES OF ACCIDENT PREVENTION WORK.

By MARCUS A. DOW.

It is a great honor and a distinct privilege to be permitted to address a congress of the National Safety Council. I am asked to speak of the progress and possibilities of accident prevention work and I feel somewhat in doubt as to my ability to do full justice to a subject encompassing such a wonderful record of achievement and promising so much that is possible for the future. The possibilities for future achievement can, perhaps, be fairly measured by a survey of what has been accomplished within a few years' time.

It is but a little more than 10 years since the United States Steel Corporation began its systematic accident prevention work and planted the seed which has brought forth a product of such great value to humanity that its development has been one of the biggest things in the history of American industry. It was a new thing—this idea that even an industry of inherent hazard could be made reasonably safe by an ethical procedure which would benefit employer and worker alike. Those pioneers who first promoted accident prevention work entered a strange and unexplored country. It was trackless, mapless and unsurveyed—the only compass there was to guide these men was a vision—a vision of a better state of affairs wherein cripples and widows and fatherless children were to be no longer a by-product of industry.

Countless obstacles were encountered by these resolute pioneers but, gropingly, they found their way and, with a determination born of a righteous purpose, they blazed their trail through the wilderness. And now, with the aid of countless others who have followed in their path, they have at last constructed a highway of progress that is surely and unmistakably extending onward and onward toward a land of promise, the like of which but a decade ago could not have been pictured in the mind of the most romantic idealist. And so the problem of preventing accidents is to-day receiving these serious and thoughtful attention of men and women in every walk of life and the effort that is being made to solve this problem is not merely the effort of a few employers but is the effort of employers and employees alike in practically every known field of industrial endeavor.

The men who inaugurated specialized accident prevention work in industries proceeded on the theory that every accident has a removable cause and that, by removing the causes, accidents could be prevented. They knew that through the application of scientific principles smallpox, cholera and other forms of epidemic could be controlled and that for any community to sit idly and wait to be devoured by such an epidemic would be cowardly and a mark of base incompetence. They realized that this also was true with respect to accidents and that it was only an ignorant fatalist who would say, "They are inevitable."

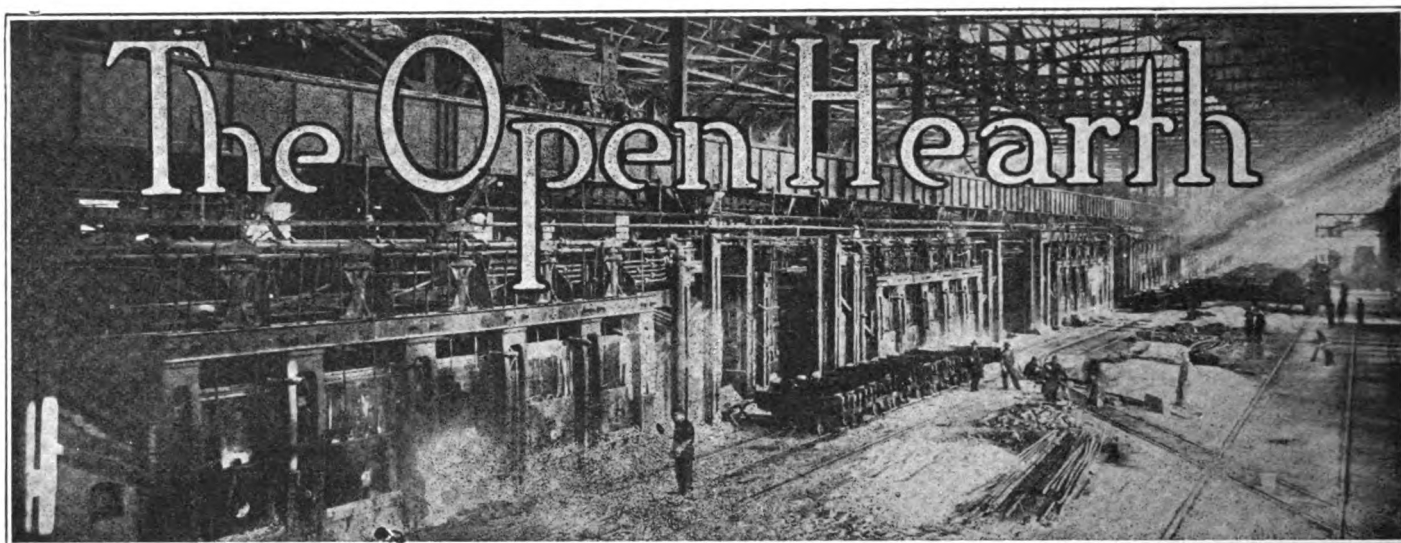
In order to remove the causes of accidents, it was necessary first to ascertain what those causes were. Therefore, one of the first steps was to classify the accidents as to specific causes. Thus, it was found that there were two elements which entered into accident prevention work. One of these was the mechanical element, involving the application of safety devices and the correction of unsafe physical conditions. It was found, however, that a majority of accidents could only be prevented by care and thoughtfulness on the part of human beings involved in accidents. Thus, the human element became an important factor to be considered and, as the work progressed, the principal avenue in which accident prevention effort was directed became the education

and supervision of the human forces. It was found that the making of laws and the mere installation of the best of mechanical safety devices would not eliminate the human element from the accident problem and that cooperation between the employer and the employee to eliminate not only the unsafe conditions which the employer must correct, but also to eliminate improper practices on the part of the employees, was essential to success in the preventing of accidents.

Before proceeding further with a discussion as to the progress, it may be well to consider the necessity of accident prevention work. It is unfortunate that there are no reliable statistics of accidents occurring in the United States as a whole. Estimates based on figures gathered from various sources, however, give conclusive proof that the waste of human material due to preventable accidents each year is nothing short of appalling. A careful estimate prepared by Dr. Frederick L. Hoffmann, statistician of the Prudential Insurance Company of America, shows that in 1916 there were approximately 22,000 persons killed in industrial accidents and that at least half a million were so seriously injured that they lost more than four weeks from work. This estimate is considerably lower than a similar estimate made three years previous, due to the effect of accident prevention work. But in the past 10 years, if the number killed in accidents each year had been as low as it was in 1916, the lives of 220,000 industrial workers—men who form the very bone and sinew of the nation—have been snuffed out. If that 220,000 had been buried in a gigantic trench, side by side, and shoulder to shoulder, that trench would now be more than 80 miles long and would have to be lengthened eight miles each year to accommodate the remains of the poor unfortunates who continue with unceasing regularity to fall victims of preventable accidents. If the hospital cots of those seriously injured in the 10 years could be placed end to end in a continuous, unbroken line, that line would completely cover a single track railroad extending as far as from New York to San Francisco and back again. More than 2,500 workers were killed in the industries of the State of Pennsylvania alone during the year 1916, and 250,000 were injured, including both trivial and serious injuries. In the State of Ohio in that same year the total number of accidents reported to the industrial commission reached the staggering total of 166,200, of which 847 were fatal. The cost in compensation for accidents in Ohio during the year mentioned was in excess of five million dollars, while the medical expenses amounted to more than a million and a half. In Massachusetts there were more than 135,000 non-fatal and 463 fatal injuries to industrial employees during the year ended June 30, 1916, while in the State of New York, in the year ending June 30, 1917, the number of men injured while engaged in industrial pursuits reached the colossal number of 328,632, of which 1,584 were fatal. With the unpleasing records of these few states, multiplied many fold by similar records in every other state in the Union, the record of each state varying only according to the number of men engaged in industrial pursuits within its borders and with many thousands more killed in accidents outside of those occurring in industries and on railroads, is it any wonder that the hearts of men should cry out against this profligate waste—this colossal injustice to the human race—and that the best brains of the nation should be devoted to the study and development of systematic means for prevention?

And so, this life-saving, health-conserving idea was conceived and has since been marching forward with "seven-league boots." It is not my intention, nor would it be possible within the time at my disposal, to describe the many effective methods that have been developed in carrying on this work.

Abstract of address delivered at Sixth Annual Congress of National Safety Council, Hotel Astor, New York City.



The following were elected to active membership of American Iron and Steel Institute:

D. E. Armstrong, secretary, The William Kennedy & Sons, Ltd., Collingwood, Ont., Can.

Walter W. Leck, Bethlehem Steel Company, Steelton, Pa.

Elmer C. Sattley, Page Steel & Wire Company, Pittsburgh, Pa.

Rudolph Tencher, Keystone Steel & Wire Company, Peoria, Ill.

William M. Tobias, Bethlehem Steel Company, South Bethlehem, Pa.

Stillman W. Wheelock, Carnegie Steel Company, New Orleans, La.

The following were elected to associate membership March 2, 1918:

Clarence L. Altemus, Pacific Commercial Company, 11 Broadway, New York City.

Charles A. Barnes, chief, Bureau of Iron and Steel Scrap, Philadelphia, Pa.

Francis John Burd, The Cutler-Hammer Manufacturing Company, Pittsburgh, Pa.

W. Rowland Cox, 120 Broadway, New York City.

Charles Dreifus, Pittsburgh, Pa.

James F. Foster, vice president, The Republic Metalware Company, Buffalo, N. Y.

J. H. France, General Refractories Company, 111 Broadway, New York City.

David M. Griffith, Wilputte Coke Oven Corporation, 6 Church street, New York City.

Roy G. Hird, The Republic Metalware Company, Buffalo, N. Y.

Albert L. Johnson, vice president, Corrugated Bar Company, Buffalo, N. Y.

Maurice Joseph, vice president, Ohio Falls Iron Company, Cincinnati, O.

Henry J. Klaer, vice president, Penn Seaboard Steel Corporation, Philadelphia, Pa.

Harold A. Lomax, Mackintosh, Hemphill & Co., Pittsburgh, Pa.

John F. Lucey, president, Lucey Manufacturing Corporation, Woolworth Building, New York City.

W. H. Pavitt, Wilputte Coke Oven Corporation, 6 Church street, New York City.

Ernest Suffern, 96 Wall street, New York City.

George R. Sullivan, Rogers Brown Company, Philadelphia, Pa.

V V

Floyd K. Smith will assume duties as vice president of the Donner Steel Company June 1.

H. C. Thomas, assistant general superintendent of the Gary works of the Illinois Steel Company, at Gary, Ind., has resigned his position to take effect April 1. Mr. Thomas has been connected with the Gary works for 10 years, the first two years of which he was engaged as chief chemist and metallurgist, and shortly after beginning operations, about eight years ago, was appointed to the position of assistant general superintendent of the plant. Mr. Thomas' successor has not been named. C. P. Kimmel has been appointed assistant superintendent in direct charge of rolling mill operations.

V V

J. C. Holding, formerly in the bureau of structural shapes and plates of the Carnegie Steel Company, has resigned and will enter the sales department of the Midvale Steel & Ordnance Company.

V V

John S. Agey has accepted a position as assistant superintendent of one of the Donner Steel Company's mills, Buffalo, N. Y. He has been in the employ of the Carnegie Steel Company, at Youngstown, O., for 13 years.

V V

I. E. Edwards, who was chief engineer for the Valley Mold & Iron Corporation, Sharpsville, Pa., for 12 years, has taken up a position with the Marshall Foundry Company as works manager of the ingot mold foundry.

V V

Peter Benninghoffen, of Hamilton, O., and F. H. Snyder, of Massillon, O., were added to the directorate of the Central Steel Company, Massillon, O., at the annual meeting of that company.

V V

Charles T. Meily will succeed J. Stanford Brown, resigned, as a director of the Carpenter Steel Company.

V V

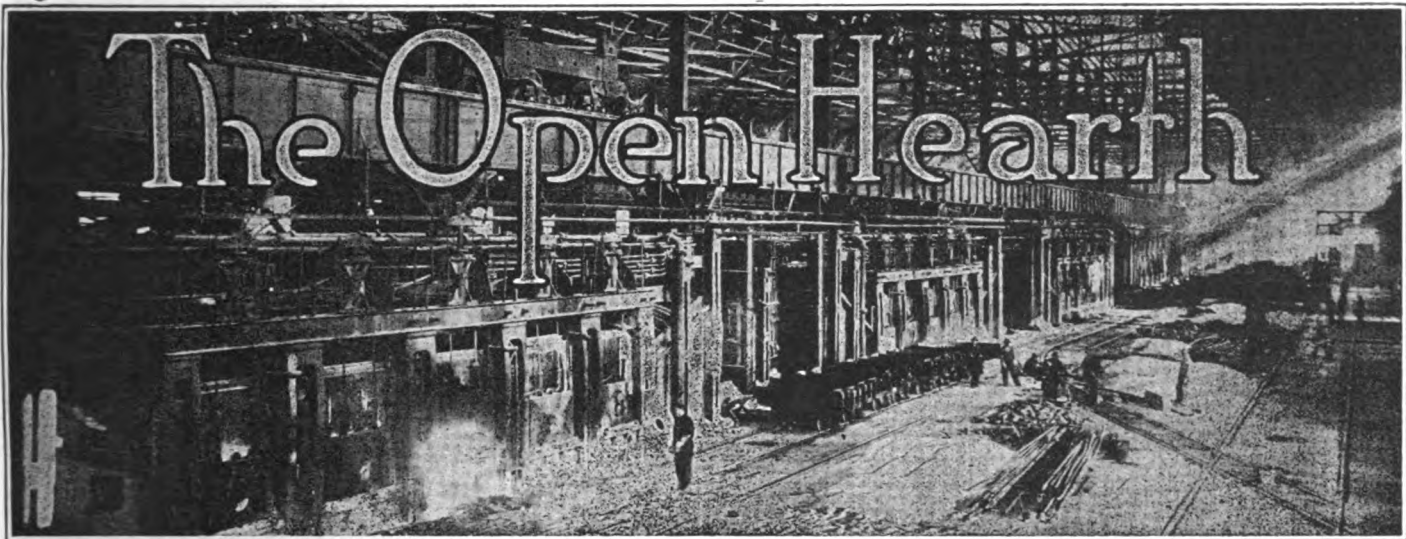
O. M. Hibler, of Youngstown, O., has been made treasurer of the Liberty Steel Company, Warren, O. He succeeds Edward F. Clark and assumed his duties April 1.

V V

C. E. Middleton has charge of ingot and plate output at the Penn Seaboard Steel Corporation, Philadelphia, Pa. H. J. Klaer is in charge of castings production.

V V

John Haddon has been appointed blast furnace superintendent at the North Lebanon furnaces, of the Bethlehem Steel Company, and James E. Gledhill, manager of the North Lebanon plants. Harrison Prindle, formerly assistant superintendent of the Colebrook furnaces, has been promoted to the position of superintendent.



H. A. Brassert, who has been connected with the United States Steel Corporation since its organization, has resigned his position as assistant general superintendent of the Illinois Steel Company, at South Chicago, in order to devote himself to his personal interests. As vice president of the Miami Metals Company and subsidiary companies, he will have charge of their operations in the production of ferro-manganese. Mr. Brassert will also act as consulting engineer for Freyn & Co., engineers and contractors. He will associate himself with Messrs. Francis H. Hardy and Chester D. Tripp, in the firm of Brassert, Hardy & Tripp, to act in a consulting and advisory capacity on commercial and operating problems in the iron and steel and affiliated industries. Mr. Brassert will remain in Chicago, with offices in the Peoples Gas Building.

✓ ✓

Aldric Thompson has opened an office at 120 Broadway, New York, under the name of Aldric Thompson, Jr., Inc. Mr. Thompson was formerly chief engineer of the International Steel & Ordnance Corporation. He will be engaged in consulting and industrial engineering work.

✓ ✓

J. S. Green, master mechanic and erecting engineer for the Wickwire Steel Company, will be connected with the Edgewater Steel Company, Pittsburgh, Pa.

✓ ✓

R. L. Hibbard, who was connected with the Riter-Conley Company for 15 years as assistant manager and gas engineer, has opened an office in the Jenkins Arcade Building, Pittsburgh, Pa., as a consulting engineer.

✓ ✓

Frederick H. Willcox has been appointed secretary, and C. D. Rawstrone, vice president, of the firm of Freyn & Co., Chicago, Ill. Mr. Willcox was formerly with the Bureau of Mines, also assistant blast furnace superintendent of the National Tube Company. Mr. Rawstrone was formerly connected with the George A. Fuller Company.

✓ ✓

James P. Armel has been appointed a senior inspector with the aviation section of the signal corps. He is in charge of inspection at The Bristol Company, Waterbury, Conn. He was formerly engineer on special design estimates with the Pittsburgh Valve, Foundry & Construction Company.

✓ ✓

J. T. Larimer, formerly assistant general superintendent of the Joliet plant of the Illinois Steel Company, is now assistant superintendent of the South Works plant, succeeding C. L. Danforth, Jr.

J. H. Walsh has been appointed superintendent of rolling mills at the South Works of the Illinois Steel Company. This is a newly-created position.

✓ ✓

Edgar C. Felton has been appointed Federal examiner for the Delaware Valley shipbuilding industry. He was formerly president of the old Pennsylvania Steel Company.

✓ ✓

J. B. Henry, general superintendent of the United Steel Casting Company, has been elected a vice president. Mr. Henry succeeds J. B. Allen, who has been elected president. Both the offices of general superintendent and vice president will be filled by Mr. Henry.

✓ ✓

W. M. Faber, plant engineer of the American Steel & Wire Company, has been made chairman of the fuel service committee of the Cleveland Engineering Society.

✓ ✓

Morris Metcalf, vice president of the American International Steel Corporation is assuming the office of the president pending the election of a president to succeed the late Edward McKim Hagar.

✓ ✓

Ross H. McMaster, formerly assistant general manager of the Steel Company of Canada, at Montreal, is now a member of the Canadian war commission. He will be located in Washington.

✓ ✓

J. Leonard Replogle has resigned as chairman and director of the Wharton Steel Company. J. H. Hillman, Jr., has been elected director.

✓ ✓

Victor E. Edwards, vice president Morgan Construction Company, Worcester, Mass., is now at Aberdeen, Md., as consulting engineer for the Ordnance Department.

✓ ✓

Charles T. Mason is now assistant general superintendent of the Joliet plant of the Illinois Steel Company.

✓ ✓

J. B. Mansfield, formerly superintendent of the Bolles Iron & Wire Works, Detroit, Mich., later vice president, has been elected president and general manager of that firm.

✓ ✓

Walter E. Brown, for many years office manager of the Youngstown Iron & Steel Company, Youngstown, O., and recently with the Sharon Steel Hoop Company has resigned. He will take charge of the farms of Jonathan Warner, president of the Trumbull Steel Company.

WITH THE EQUIPMENT MANUFACTURERS

A PLASTIC REFRACTORY FOR BOILER BAFFLES.

The principal loss of heat from a boiler furnace is in the flue gases, and is measured by the product of their weight multiplied by their excess of temperature over atmospheric temperature. High temperature of gases may be due to coming into contact with too little heating surface, to coatings of soot or scale upon the heating surface which prevent the absorption of heat from the gases, but most commonly, to defects in the baffling. Baffles may be improperly located, producing deadspaces where the gases do not circulate in the tube banks of water tube boilers, or the baffling may not provide for a sufficiently high velocity and long path of the gases of combustion.

Defective baffling is the most common cause of high chimney temperatures. The baffles may have fallen down or bricks or blocks may have slipped out from between the boiler tubes, allowing the short-circuiting of a large amount of gas.

The strongest reason for the installation of pyrometers to measure flue gas temperatures is that they serve to notify the operating force at once regarding baffle failures. Where abnormally high temperatures are found, a broken-down baffle is always to be expected.

Baffles for water-tube boilers have in the past consisted of tile, bricks or blocks of refractory material, fitted in between the tubes. In cross-baffled boilers these tiles are introduced between the tubes by springing the latter, and naturally do not form very tight joints with one another or with the tubes, especially after the latter have become warped or sprung as they invariably do in service. It is also difficult to insure that blocks will remain where they are placed and will not slip or fall, leaving large openings. Due to the manner in which baffles are inserted in boilers, it is almost impossible to cement them together, besides which the difference in expansion and contraction of the boiler and baffling would break the joints apart. Brick and blocks also warp and twist and are frequently split by the pinching effect of the tubes.

The accompanying illustration shows how jointless, and, therefore, gas-tight baffles can be made by the use of a refractory known under the trade name of Plastic Fire Brick and manufactured by the Betson Fire Brick Company, of Rome, N. Y. This material was originally introduced for lining boiler furnaces, and is compounded of refractory materials so prepared as practically to eliminate expansion and contraction with changes in temperature.

The material is shipped in barrels in a moist, plastic condition, ready for use. In forming a cross-baffle for a water-tube boiler of the B. & W. type, the ordinary cast iron baffle plate is used as one side of the mold, while the other is made by thrusting slats in through the diagonals between the tubes, as shown in the illustration. The plastic material is then

poked down through the diagonals to fill the space between the cast iron baffle plate and these slats. It is sufficiently plastic so that it can be forced out sidewise around the tubes, fitting the latter snugly.

When this work has been completed, the boiler is fired up slowly, the criss-cross of slats burns out, and the plastic material is dried and vitrified in place. This operation occupies only a few hours, after which the full load may be put upon the boiler. Inasmuch as the boiler comes up to full steam pressure before the material is thoroughly set, the expansion of the metal pushes away the soft material to the position which it should occupy when the boiler is hot, and while the boiler will draw away from the material in cooling off again, the baffles will always fit tightly when the boiler is under steam.

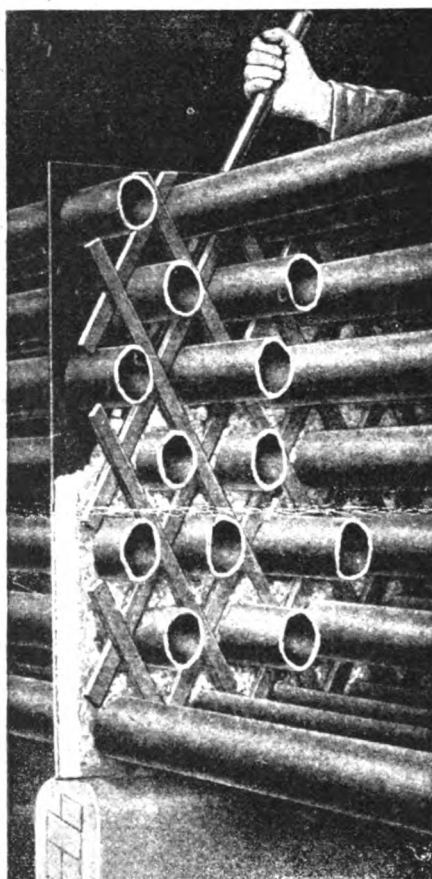
In forming a longitudinal baffle, blocks of wood are placed in between the tubes, above and below the space which it is desired that the baffle shall occupy, thus confining the plastic material, which is shoved in from the side in the case of baffles in the middle of the tube bank, or from underneath or overhead, in the case of the baffles at the bottom or top of the tube bank.

Where this material is used there is no restriction upon the shape or size of the baffle, and the latter can therefore be arranged in any form desired. In cross-baffled boilers, for example, it is becoming the practice to slope or incline the baffles so that the gas passage will contract progressively from the point where the gases enter the tube to the point where they leave, in order to maintain a uniform gas velocity, in spite of the shrinkage of gas volume with cooling. This is easily accomplished with the plastic material, whereas with the solid bricks or blocks a special block is required which can be inserted and maintained in place only with difficulty, if at all.

This material also finds use as a substitute for special forms of bricks or blocks, as for example, where the front headers of horizontal water-tube boilers rest upon the front arch. Its use for lining furnace and combustion chambers, wall, rear arch, etc., has been described including front arch, side walls, bridge

scribed previously. The exacting tests to which it has been put in direct contact with the fuel bed and with the gases of combustion before they have been cooled by the boiler surfaces, proves its ability to withstand high temperature gases and stresses such as are encountered in furnace construction for long periods without crumbling or otherwise deteriorating.

Driver-Harris Company, Harrison, N. J., have recently issued an extensive bulletin on the subject of "Pure Sheet Nickel." Another bulletin on "Nichrome" wire mesh containers for heat treating and acid cleaning is in preparation.

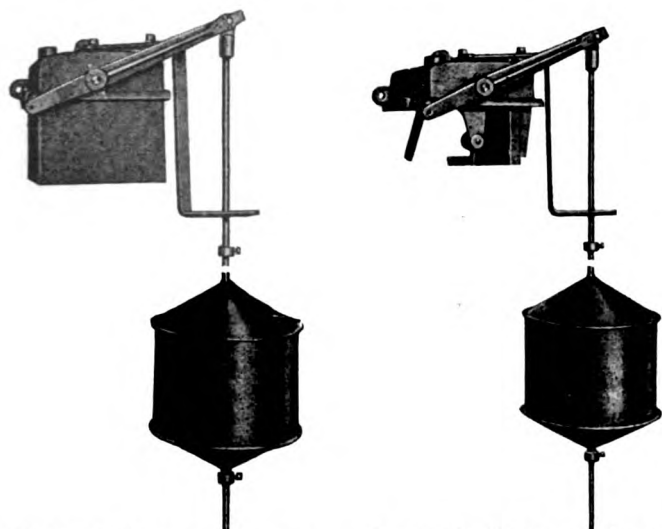


Method of placing and compacting the material, which is retained in place by criss-cross of slats until set by the fire.

WITH THE EQUIPMENT MANUFACTURERS

NEW ENCLOSED FLOAT SWITCH FOR AUTOMATIC CONTROL OF PUMPS.

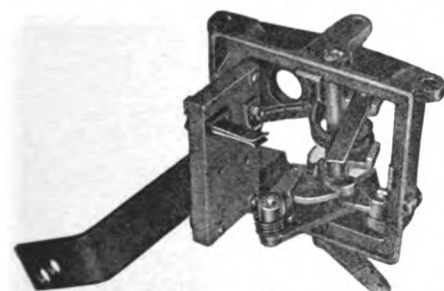
Perhaps some of the first float switches were used in connection with sump pumps in basements of buildings, but present-day uses of these switches cover a wide field of manufacturing and industrial applications. One of the im-



Enclosed float switch with lower enclosure removed.

Enclosed float switch arranged for fall mounting.

portant applications in connection with motor-driven pumps is for sprinkler systems and other fire protective apparatus. As an improvement on the open type float switch, The Cutler-Hammer Company of Milwaukee, Wis., is now manufacturing a new enclosed switch which is built to stand hard usage and has a switching mechanism that is positive in its operation. The opening and closing of the switch blades is accomplished by the rise and fall of a heavy copper float, which by means of a float rod and lever drives a roller, against the action of a spring, over the point of a cam. This opens and closes the switch with a quick action. The switch will not get out of step, which is the chief objection to some switches. The upper part of the C-H switch carries all of the operating mechanism and is also provided with mounting lugs. They are made for several different methods of mounting. The en-



Showing mechanism of enclosed float switch.

closing tank can be easily removed for inspection or making connections. The upper casting is provided with an opening and bushing for the entrance of conduit. These switches are made with one, two, three, and four poles. The single pole switches are intended for use with self-starters for automatic controlling direct or alternating-current motors. The two, three and four-pole switches are intended for use with single and polyphase motors which may be thrown directly on the line when starting.

ELECTRIC HOIST MANUFACTURERS ORGANIZE.

The Electric Hoist Manufacturers' Association has, by a resolution adopted at its last meeting, offered the services of the member companies to the government in meeting the extraordinary demand for their product.

The War Industries Board of the government has requested full information concerning the ability of the electric hoist manufacturers to handle the volume of business offered them, as well as what effect priority orders and embargoes on shipments has had upon the trade.

Electric hoists for shop use and handling material have gone through various stages of development during the past 15 years and like all classes of shop machines they cannot be successfully designed on the basis of theory alone. Actual experience in meeting hoist requirements and innumerable corrections and refinements in design on the part of the manufacturers have marked the progress made during these past 15 years in this important field.

Now that it is thought that the experimental stage has been well passed and acceptable designs developed by various manufacturers, it seems wise to coördinate the total experience and to make available for the user all that is best in electric hoist design and practice. With this object in view, the manufacturers of the United States organized "The Electric Hoist Manufacturers' Association," comprising the following companies:

The Brown Hoisting Machinery Company.
Detroit Hoist & Machine Company.
Euclid Crane & Hoist Company.
The Franklin-Moore Company.
Link-Belt Company.
Roeper Crane & Hoist Works.
Shepard Electric Crane & Hoist Company.
Sprague Electric Works.

The Yale & Towne Manufacturing Company.

The officers of the association are:

F. A. Hatch, chairman, Shepard Electric Crane & Hoist Company.
F. W. Hall, vice chairman, Sprague Electric Works.
C. W. Beaver, secretary-treasurer, The Yale & Towne Manufacturing Company.

The association holds monthly meetings for the purpose of studying the specific needs of the hoist user and to develop standardized methods of presenting information to him so that guesswork will be eliminated.

The association will consider uniform nomenclature pertaining to types and parts of electric hoists, fix upon a standard by which hoist motors shall be rated, and promote the standardization of electric hoists as far as possible. It will also collect and disseminate information and statistics relative to the electric hoist industry, provide facilities and opportunities for study and education in regard to the economics of the industry, extend the use of their product by pointing out the great number of material-handling problems of different classes that can be solved by the use of electric hoists, promote a friendly intercourse and coöperation among the members and disseminate information that long experience has taught is essential to any hoist to insure good results and to recommend to the members of the association well established principles, both as to construction and equipment, that will tend to eliminate any possibility of inferior equipment.

Trade Publications

Roller Chains—The Link-Belt Company, of Chicago, Ill., has issued book No. 358, containing preliminary information on recent roller chain developments. A table of dimensions of roller chains, specifications, etc., are included in the booklet which is well illustrated.

Steel Wheels for Trucks — Detroit Pressed Steel Company, Detroit, Mich., has issued a folder which deals with a line of heavy-duty pressed steel disc wheels for trucks and tractors. Drawings of the three styles of wheels which are made are presented, there being practically no text in the folder.

Superheaters — Power Specialty Company, 111 Broadway, New York, has issued a pamphlet which calls attention to a line of superheaters and the advantages of using them in connection with the employment of steam for power purposes. Illustrations of the different forms of superheaters that can be supplied are presented, together with views of a number of plants in which they have been installed. Mention is made of units for use on locomotives and steamships and for portable work.

Ball Bearings—Transmission Ball Bearing Company, Inc., Buffalo, N. Y., has issued catalog No. 3. Size 6 x 9 in.; 52 pages. It describes and illustrates an extensive line of ball bearings for power transmission. These include standard and heavy-duty types for shafting hangers, pillow blocks, loose pulleys, clutch sleeves, etc. A brief account of the development of the bearings is presented together with the results of tests which have been made upon them. Tables of sizes are presented in each case and a number of views of applications of the bearings as well as plants in which they have been installed supplement the text matter.

Soot Blowers—Bulletin No. 119, just issued by the Diamond Power Specialty Company, is a handsome 48-page review of current mechanical soot-blower practice. The bulletin is printed in two colors throughout, and contains in addition to many fine illustrations much data on boiler-room efficiency, going into detail regarding the necessity of equipping boilers with soot blowers of the highest operating efficiency to be obtained. Charts, tables and illustrations make very clear the method of cleaning.

Trade Notes

The Pittsburgh office of the Reliance Iron & Coke Company, of which Ray S. Fox is manager, has been moved to 1226 Park building, in that city.

The Lees Company, successor to George E. Lees Advertising, has moved their office from 2025 East Ninth street, Cleveland, O., to 422 Sloan Building.

Beginning at once, the address of the Hyatt Roller Bearing Company is as follows: Hyatt Roller Bearing Company,

Industrial Bearings Division, Metropolitan Tower, New York City.

The Easton Car & Construction Company, Easton, Pa., announce the opening of a new branch office in Washington, D. C., the address being 225 Kellogg Building, 1422 F street, Northwest.

The Asbestos Protected Metal Company, of Pittsburgh, Pa., has announced the removal of its New England office to the State Mutual Building, in Boston, Mass. William H. Cummings is in charge.

A transfer of its general purchasing office from St. Louis to the main office, 165 Broadway, New York, has been made by the American Car & Foundry Company. W. H. Hedgecock is general purchasing agent.

The Wilson-Synder Manufacturing Company has opened an office in Cleveland, O., 511 Citizens Building. H. W. Van Cleve, formerly of the Pittsburgh office has been made district manager of Cleveland branch.

The Westinghouse Electric & Manufacturing Company has removed its Phoenix branch to the Immigration Building, Tucson, Ariz. The Southwestern representatives are J. H. Knost and W. G. Wilson.

A branch office has been opened in Chicago by the Latshaw Steel & Metal Products Corporation, New York. The Chicago branch is located in the Railway Exchange Building. Marvin W. Singer is in charge.

Mayer Bros., Inc., Antigo, Wis., power hammers, will move its plant and offices to Kaukauna, Wis., where it has secured the factory and business of A. W. McLean & Co. The latter company has been doing business under the name of the Kaukauna Machine Works.

A Washington office has been established by the Cutler-Hammer Manufacturing Company. H. W. Knowles, of the New York office has been put in charge and the office is to remain at the capital for the period of the war. The Washington headquarters will be at the Bradford, Eighteenth and K streets.

A. B. Morrison, Jr., has recently accepted a position with the Smith Gas Engineering Company as sales engineer. Mr. Morrison was formerly with the Fort Wayne Electric Works and the Rathbun-Jones Engineering Company and more recently with the John H. McGowan Company as Philadelphia representative.

The general offices and branch sales office of the American Refractories Company are now located at suite 315 Union Arcade Building, Pittsburgh, Pa. The general sales offices will be located at 208 South La Salle street, Chicago, Ill. A branch sales office will be opened in the Equitable Building, 120 Broadway, New York.

Julius S. Holl, formerly advertising manager of the Link-Belt Company, Chicago, Ill., and who was recently appointed assistant head of the department of shipyard volunteers of the United States

shipping board has been engaged in the enrollment of 250,000 volunteer workers for shipyards. His office is located at 207 National Theater Building, Washington, D. C.

Earl E. Adams, lately sales manager of powdered coal department of the Bonnot Company, Canton, O., and for some years in charge of gas producer work for the Power & Mining Machinery Company, has accepted a position as sales engineer for the Smith Gas Engineering Company and will shortly be located at Dayton, O., where the new plant of the Smith Gas Engineering Company is nearing completion.

The Camden Iron Works, of Camden, N. J., is now being operated directly by the receivers, their agreement with Walter Wood, trading as R. D. Wood & Co., to act as their agent, having terminated on February 28. The receivers are operating under the direction of the United States Court. All proposals, contracts, purchases, shipments, payments and collections are now being made by the receivers from or at their office, in Camden, N. J.

Obituary

George England, who was superintendent of the foundry at Edgar Thompson Steel Works, Carnegie Steel Company, Braddock, Pa., died at his home recently.

A. Russel Calder died at Harrisburg, Pa., 60 years of age. He was connected with the Pennsylvania Steel Company, Steelton, Pa., for 35 years. He assisted in the first heat of basic Bessemer steel made in this country.

Henry B. Newhall, formerly president of the Newhall Chain, Forge & Iron Company, the New Jersey Foundry & Machine Company, the Diamond Expansion Bolt Company, and the Garwood Company, died February 16 at Littleton, N. H., after a long illness.

Society Meetings

The summer meeting of the American Institute of Chemical Engineers will be held June 19-22 at the Madison House, Gorham, N. H.

The second annual convention of the American Gear Makers' Association will be held at the Green River Hotel, Wichita Sulphur Springs, W. Va., April 18-20.

The Pittsburgh section of the A. I. E. E. will meet Tuesday evening, April 9, at the Chamber of Commerce Building, Pittsburgh, Pa. A paper on Induction Motors will be read.

The spring meeting of the American Electro-chemical Society will consist of a trip through the South, beginning the week of April 28. Chemical, electro-chemical and metallurgical centers of the South will be visited. During the evenings technical papers and discussions will be held.

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Pittsburgh, April, 1918

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